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MARCH, 1916

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ANNALS

OF

The Entomological Society of America

Volume IX MARCH, 1916 Number 1

A REVIEW OF APPLIED ENTOMOLOGY IN THE BRITISH EMPIRE.*

By C. Gordon Hewitt, D. Sc., F. R. S. C.,
Dominion Entomologist, Ottawa, Canada.

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*The Annual Address to the Entomological Society of America, delivered at Columbus, Ohio, on December 29th, 1915.

In the selection of the subject of my address I had as my main motive the bringing of the entomologists of this country into closer touch with a large body of entomologists who are studying an infinite variety of problems in those widespread territories of the earth's surface that together constitute the British Empire. This more intimate acquaintance is desirable for many reasons, but I will refer only to two of them. First, our Society recently decided to extend its membership outside the confines of North America and as a result a number of British workers, which number I am confident will increase, have been included on our membership rolls; I wish to introduce these members and some of their problems to you. Secondly, it is becoming increasingly apparent that the control of insect pests and the successful prosecution of entomological investigation, be it along practical or purely scientific lines, must be along international lines. Our experience, especially during recent years, has clearly demonstrated this fact, particularly in regard to the control of insects by their natural enemies. From the time when Koebele visited Australia in 1885 and brought the now famous Coccinellid *Novius cardinalis* to save the citrus groves of California from destruction up to the recent world tour of Silvestri in search of parasites of the fruit-flies, we have had repeated instances of the incalculable value of international co-operation; but it would involve too great a digression to mention even the more important of these. In this line of investigation alone there lie immense possibilities which will be made more easy of realization to the benefit of all concerned by a more intimate knowledge of other workers and their problems in other parts of the world. Such a review as I propose to give will, I feel confident, show clearly how the British Empire by its widespread character and diversity of conditions of every kind, offers an unequalled opportunity for international co-operative effort, particularly to the Entomologists of the United States. The establishment of a chain of workers in all the continents which would result from such co-operation would have beneficial results of the most far reaching character on the entomological work of the future. If I am able to further the object to which I have referred, I shall consider that the time I am about to take up has indeed been well spent.

The countries that enjoy the benefits of British forms of government comprise territories from equatorial to arctic and antarctic latitudes; they include some of the most worthless and barren regions of the world's surface and some of the richest and most fertile. Consequently we find every type of vegetation, every kind of crop and every form of insect life to which such vegetation or crop may serve as sustenance. In addition there are few types of insect-borne disease that are not found somewhere within British domains. It will not be possible, therefore, to do more than briefly touch upon the more outstanding features of the work that is being carried on in those countries by an ever increasing body of highly trained and enthusiastic workers. And here I would remind you that it is one of the chief characteristics of the British entomologist that he usually follows his profession on account of his enthusiasm for the subject, and in spite of the remuneration that he receives and the natural difficulties with which he has to contend.

BRITISH ISLES.

The Imperial Bureau of Entomology.—The formation of the Imperial Bureau of Entomology in 1913 was the outcome of an effort made a few years earlier to further entomological investigations in the British possessions in tropical Africa. Early in 1909 Dr. A. E. Shipley, Master of Christ's College, Cambridge, drew up a memorandum, with some slight assistance from me, for the Secretary of State for the Colonies, Lord Crewe, and as a result of this a meeting was called in March, 1909, to discuss the formation of an entomological research committee for the stuty of entomological problems, particularly those relating to tropical diseases, in tropical Africa. Such a committee was formed that year and it included the chief experts in entomology and tropical medicine in Great Britain and Ireland, with Lord Cromer as Chairman. Its work fell under three divisions, namely, the carrying on of investigations and entomological surveys in tropical Africa, for the purpose of which two travelling entomologists, Mr. S. A. Neave and Dr. J. J. Simpson, to whose work reference will be made later, were employed; the determination of entomological material, and the publication of the work so accomplished, for which purpose the *Bulletin of Entomological Research* was started as a quarterly journal.

The valuable service rendered by this committee soon led to an enlargement of its scope. After a consideration of the matter by the self-governing dominions, and a conference of the committee and of the entomologists of some of the dominions and colonies in 1912, a scheme for imperial co-operation in preventing the spread and furthering the investigation of noxious insects was worked out. This conference put forward a proposal for the establishment of an Imperial Bureau of Entomology, to be financially supported by the various dominions and colonies and the British government. The scheme was adopted by the various self-governing dominions and colonies which were invited to co-operate and contribute to the maintenance of the Bureau, and the crown colonies and British protectorates are also participating in the advantages of the Imperial Bureau of Entomology which was established in 1913 with headquarters in London. The former Entomological Research Committee has become the Honorary Committee of Management on which committee the government entomologists of the dominions are also members. The Rt. Hon. Lewis Harcourt, former Secretary of State for the Colonies, is Chairman of the Committee and Dr. Guy A. K. Marshall is Director of the Bureau and Editor of its journals.

The functions of the Bureau are as follows:

1. The collection and co-ordination of information concerning the noxious insects of the world so that any British country may learn by enquiry what insect pests it is likely to import from other countries and the best methods of preventing their introduction and spread.

2. The authoritative identification of insects of economic importance submitted by the officials of the Departments of Agriculture and Public Health throughout the Empire.

3. The publication monthly of the *Review of Applied Entomology* in which concise summaries or abstracts are given of all the current literature which has a practical bearing on the investigation and control of noxious insects.

4. The investigation of blood-sucking insects, particularly in Africa. At present all the field staff are engaged in studying the bionomics of the various species of *Glossina;* the special object of their investigations is to endeavour to devise some practical means of reducing the numbers of or eradicating these

carriers of the different types of *Trypanosomes*. The men engaged in this work are Mr. W. F. Fiske and Dr. G. D. H. Carpenter, in Uganda, Dr. W. A. Lamborn in Nyasaland and Dr. J. J. Simpson in the Gold Coast.

The work of the Bureau is wholly different from that of the United States Bureau of Entomology. Its primary function is that of an intelligence bureau, a clearing house for entomological information, collecting such information for the use of the British countries supporting it. It has already accomplished a large amount of useful work and has been of particular assistance to those isolated and scattered British territories where the entomologists and medical officers suffer from lack of museums, libraries and co-workers which they would wish to consult. International as the scope of its survey necessarily is, it has already demonstrated how valuable a similar Bureau properly constituted on international lines might prove.

England. The British Government in the past has not maintained an official entomologist or entomological staff. The Board of Agriculture and Fisheries has been content to retain the services of an outside entomologist to prepare replies to any entomological inquiries submitted to it by farmers and others, and their leaflets have been chiefly the work of unofficial advisers. In the absence of an official entomological staff the investigation of insects affecting agriculture has been left in the hands of men such as Prof. F. V. Theobald of the South Eastern Agricultural College who is now making a much needed study of the British aphides and whose work on mosquitoes is well known, Mr. C. Warburton of Cambridge, Prof. Newstead of Liverpool, Mr. W. E. Collinge, and others.

It is perhaps difficult on this continent to understand the underlying reason for the scant development of "official" entomology in England. But it must be pointed out that agricultural conditions are entirely different in such old countries where there is a more intensive system of farming, a consequent closer supervision of crops, cleaner cultivation and long developed systems of rotation. More especially, the comparative stability of the agricultural conditions has produced a more perfect balance in all those natural conditions the disturbance of which in more lately developed countries leads to an abnormal behaviour of the insects which are potentially noxious. These facts should, therefore, be borne in mind in considering the apparent lack of any extensive development in applied entomology in the older European countries.

In 1912 the Horticultural Branch of the Board of Agriculture and Fisheries was established under the direction of Mr. A. G. L. Rogers. This branch has the administration of the Destructive Insects and Pests Act to carry out which legislation five trained inspectors are employed. Their work, however, is at present largely concerned with plant diseases. An advance was made in 1913 when Mr. J. C. Fryer was appointed Entomologist to the Board. His work is primarily of an advisory character, advisory to the Board in regard to legislation and to the public by means of letters or leaflets. He also studies epidemic pests and insects of unusual importance. For example, Mr. Fryer has begun a study of the species of *Hyponomeuta* the Ermine Moths, whose introduction into the State of New York afforded Mr. P. J. Parrott an opportunity of studying them in a new environment. The Narcissus Flies, *Merodon equestris* and *Eumerus strigatus* have also been studied. Mr. Fryer informs me that he is now studying *Hylemyia coarctata* a serious wheat pest in low-lying marshy districts. Capsid bugs, which cause similar injuries to fruit to those with which we are familiar in the northeastern region of North America, are also receiving attention.

Entomological investigations are also conducted at certain of the universities by means of grants from a Government Development Commission Fund. It would appear to be the intention to foster the investigation of insect pests in recognised university departments rather than in a department of the government, a plan which has advantages and disadvantages which I will not discuss here. As a result there is a Department of Agricultural Entomology at the University of Manchester under Dr. A. D. Imms, and forest insects are studied at the University of Oxford. Prof. Maxwell Lefroy of the Imperial College of Science and Technology, London, has also been conducting investigations in applied entomology.

Scotland. A few years ago a separate Board of Agriculture for Scotland was established and Dr. R. Stewart McDougall of the University of Edinburgh acts as Entomologist to the Board. Dr. McDougall's work is largely concerned with forest insects but his work on the Sheep Maggot Flies, *Lucilia* spp., is well known.

Ireland. Prof. G. H. Carpenter of the Royal College of Science, Dublin, acts as Entomologist to the Department of Agriculture and Technical Instruction of Ireland and publishes an annual report on economic entomology in the Proceedings of the Royal Dublin Society. Prof. Carpenter's investigatory work during a number of years has been confined chiefly to the study of the Warble Flies, *Hypoderma bovis* and *H. lineata.*

AFRICA.

On no other continent in the world has the struggle between insect and man been so acute as on this immense area containing tropical and sub-tropical conditions, and nowhere has the insect been so victorious or so securely entrenched in regions offering every advantage to it and every obstacle to man. The mosquito has held the key to some of the richest regions of the earth's surface, the Tsetse fly has rendered extensive transportation impossible, and the tick, if one may be permitted to use entomology in its broad sense and include ticks, has kept the white man at bay and devastated his herds. But by slow degrees the power is passing from insect to man and nowhere is the conquest of such an adverse and powerful force of nature by patient effort illustrated more strikingly than in the gradual conquest, in the real sense, of Africa. The West Coast is no longer a "White man's grave," as it was formerly called, nagana and tick fevers are losing their original terrors and we should be unworthy of our traditions did we believe that sleeping sickness would always remain the scourge that experience has demonstrated it to be within recent years.

The British territories in Africa are so situated that it has fallen to the lot of our investigators to contribute largely to this notable conquest, the history of which would constitute one of the finest examples of entomological achievement that we have. But to attempt to outline such a history would exceed the limits which must necessarily be set to this account of the manner in which the work is being carried on at the present time.

The Union of South Africa. Prior to the formation of the Union of South Africa the four colonies, Cape Colony, Natal, Transvaal and the Orange Free State, carried on their entomological work independently. Cape Colony which created a Division of Entomology with Mr. C. P. Lounsbury as Chief in 1895, was the most advanced. Following the union, Mr.

Lounsbury was made Chief of the new Division of Entomology of the Union Department of Agriculture with headquarters at Pretoria. The work of this Division comprises, in addition to the dissemination of advice on insect problems and the carrying on of investigations, the administration of government regulations concerning (1) the suppression of locusts, (2) the inspection of nurseries (3) plant and fruit imports, and (4) restrictions on the conveyance of plants and fruit. At Pretoria Mr. Lounsbury has Mr. Claude Fuller, former Entomologist for Natal, as Assistant Chief and is also assisted by Mr. D. Gunn and several inspectors. The following branch laboratories are also maintained: Capetown, with Mr. C. W. Mally in charge; Bloemfontein, Mr. J. C. Faure in charge of investigations in the Orange River Colony; and New Hanover, Natal, with Mr. C. B. Hardenberg in charge. In addition to the staffs at these laboratories, plant inspectors are stationed at the following ports of entry for plants and fruit: Capetown, Johannesburg, Durban, East London and Port Elizabeth. The agricultural situation in South Africa is peculiar owing to the fact that agriculture is not yet the basic industry of the country. The greater part of the agricultural lands is devoted to live stock, and the cultivation of the land is proceeding gradually. Nevertheless, the climatic conditions are eminently suitable to the cultivation of deciduous and citrus fruits with the result that progress in this direction is being made.

The development of a fruit-growing industry has naturally demanded a vigilant policy in the matter of preventing the introduction and spread of foreign fruit pests and the policy has been to restrict importations of nursery stock and to foster local nurseries. On this account nursery inspection constitutes the prominent feature of the work of the Division of Entomology. This work and the inspection of imported nursery stock and fruits and regulation of the transportation of home grown fruit is carried out under the Agricultural Pests Act of 1911.

To retard the spread of the codling moth which was introduced into the country, apple, pear and quince fruits may not be transported into certain areas. Equally stringent measures were adopted to prevent the spread of San Jose scale (*Aspidiotus perniciosus*). Undoubtedly the control of locusts constitutes one of the most serious problems in South Africa. Of the two species of migratory locusts the brown locust *Pachytilus sulcicollis* is more serious than *Schistocerca peregrina*. From the Kalahari Desert, in what has hitherto been called German South West Africa, which is the permanent habitat of the species, vast swarms migrate to Central and Eastern Cape Colony, Transvaal, Orange River Colony and Rhodesia and breed there. These swarms sometimes have a frontage of fifteen to twenty miles and a length of sixty to seventy miles and take several days to pass a given point. They devastate the veldt of all green food with serious results; in 1906 it was estimated that the locust damage in South Africa amounted to five million dollars. The control of these locusts is regulated by law. Farmers are required to report the laying of the eggs and the appearance of the young hoppers. They are also required to destroy the young hoppers and the government furnishes the poison. Arsenite of soda mixed with water and molasses or sugar is universally used and with success over large areas, the poison being usually applied by means of bucket pumps which are loaned to the farmers. This campaign necessitates the keeping in stock of a large store of prepared poison and a supply of pumps for any emergency.

Notwithstanding the large amount of administrative work, the entomologists in South Africa have undertaken important lines of investigation. Mr. Lounsbury's work on ticks is well known and Mr. C. W. Mally's name will always be remembered where poisoned baits for fruit-flies are used. Mr. Fuller has also contributed to our knowledge of the termites and Mr. Hardenberg has made extensive studies of the insects affecting the wattle.

The tick problem is a very serious one in South Africa, several most important diseases of live stock being transmitted by these agents. Of these diseases East Coast Fever, due to the protozoan parasite *Theileria parva*, which is carried by several species of ticks of the genus *Rhipicephalus*, is the most serious and has played great havoc. In addition the disease included under the general term Piroplasmosis namely, bilary fever in horses and redwater in cattle, are serious adverse factors in the main type of agriculture followed in South Africa. Fortunately the Veterinary Branch of the Department of Agriculture has attacked the tick problem in a vigorous manner along well known lines, no little credit being due to the work of Dr. Arnold Theiler.

Rhodesia. The entomological problems of Rhodesia are not very dissimilar on the whole to those of South Africa, although there are certain lines of inquiry which are peculiar to this region. Mr. R. W. Jack, the Government Entomologist has his headquarters at Salisbury and is assisted by Mr. R. L. Thompson. Their work follows along the usual lines outlined in the case of South Africa. Under the "Importation of Plants Regulations" and "Nurseries Ordinance" the Government prevents the introduction and spread of insect pests and plant diseases. Four ports of entry have been established, namely, Salisbury, Bulawayo, Umtali and Gwelo, at which fumigation houses are maintained. Nurseries must register and are inspected annually.

The country is subject to locust plagues and native commissioners, cattle inspectors and members of the British South African police are required to report with full details any swarms, for the control of which locust poison, spray pumps, etc., are kept on hand. The Government protects the chief bird enemies of the locust, such as the White Stork, Cattle Egret, Lesser Locust Bird and Wattled Starling.

Much attention has been devoted by Mr. Jack to the study of Tse-tse flies and each year he devotes a portion of his time to travelling through the "fly" belts for the purpose of making bionomical investigations and delimiting the areas of these belts. Areas infested with *Glossina morsitans* are defined by government regulations and adjacent areas, or "open areas" are also defined in which the destruction of all game, with the exception of ostriches and certain game birds, is permitted. The results of Mr. Jack's investigations have been published in the *Bulletin of Entomological Research.*

Other investigations are mainly concerned with pests of the more important crops, such as corn (maize), citrus fruits and tobacco and with the pests of lesser cereals, field crops, vegetables and stone fruits. The wide range of plants and trees cultivated on the high and low parts of the territory offer an unusual broad field for research. Tenebrionids are very common and have been studied and also pests of corn (maize). A formidable problem is afforded by certain fruit-piercing moths belonging to the genera *Maenas*, *Ophiusa*, *Achaea* and *Sphingomorpha*, which severely injure practically all fruits.

The control measures are not specially peculiar, although where cheap coloured labour is available hand-picking may be more commonly used than in other countries dependent upon white labour. A long dry season enables advantage to be taken of clean cultivation. Owing to the fact that the country is being opened up by a keen class of agriculturists who are experimenting with new crops and are not bound by the hard and fast traditions of old farming communities, the entomologists are frequently consulted and co-operation in experimental work is readily secured.

Uganda. In this rich tropical country offering great opportunities for entomological investigations, Mr. C. C. Gowdy carries on his work as Government Entomologist single-handed. The study of the Tse-tse fly problem is not carried on by the Department of Agriculture, but independently of this Department, as I shall show later. Mr. Gowdy is stationed at Kampala and the size of the country and methods of travel, namely, by the use of porters, do not permit of a very thorough study of any one problem, especially as his only assistants are natives, who are constitutionally lazy, but nevertheless make good collectors.

The importation of plants and seeds is regulated by Government Ordinances. There is a single port of entry, Kampala, and there all imported plants are inspected and, if necessary, fumigated. The importation of cotton seed is prohibited; all plants from Ceylon, coffee plants and coffee other than roasted beans and ground coffee, are prohibited without special consent. A Plant Pest Board has been created, one of its objects being to facilitate the reporting of the existence of pests and the enforcement of preventive or remedial measures.

The chief entomological problems relating to agriculture in Uganda are connected with principle crops, namely, cotton, coffee, cacao and Para rubber. Termites and locusts also demand attention.

Undoubtedly the most serious entomological problem in Uganda at the present time is the suppression of sleeping sickness by the control of the Tse-tse fly. For about thirteen years this disease, which in the earlier part of the last decade was responsible for the deaths of several hundred thousands of the inhabitants of Uganda, has been studied at Entebbe by the

Sleeping Sickness Commission, on which Sir David Bruce has been the principal worker. The entomological aspect of the question was not specially studied until comparatively recently, but now it is receiving more of the attention it deserves, and I have referred to the fact that the Imperial Bureau of Entomology has two investigators at work in Uganda, namely, Mr. W. F. Fiske, formerly of the United States Bureau of Entomology, and Dr. G. D. H. Carpenter, who have already added substantially to our knowledge of the bionomics of the Tse-tse flies. In the adjacent British territory of Nyasaland, Dr. W. A. Lamborn of the Imperial Bureau of Entomology is studying the Tse-tse fly problem.

British East Africa. The Department of Agriculture has as its Chief Entomologist Mr. T. J. Anderson, who is stationed at Nairobi, the headquarters of the government of the Protectorate. He has an assistant, a Plant Import Inspector and a staff of native collectors. The careful examination of all plants, seeds, etc., entering the Protectorate is undertaken by the Plant Import Inspector under the Regulations of the Disease of Plants Prevention Ordinance, 1910. There are special regulations relating to coffee and cotton. Facilities are provided at the Government Experimental Farm where the entomological laboratory is situated for the carrying on of entomological investigations. The most troublesome insect pest perhaps is the coconut beetle (*Oryctes monoceros*). The antestia bug (*Antestia variegata*) is very injurious to the coffee plants. Experiments are now being carried out on the control of the latter pest by an Ichneumon parasite.

Egypt. Previous to the creation of a Department of Agriculture in 1910, the Ministry of Interior and the Khedivial Society of Agriculture undertook the study of insect pests, Mr. F. C. Willcocks being the Entomologist of the Society and the Yearbooks of the Society contain the results of his numerous investigations, particularly on the Egyptian cotton worm (*Prodenia litura*) and the Egyptian cotton boll-worm (*Earias insulana*). Insects affecting cotton have received the greatest attention on account of the increasing importance of that crop. Under the Ministry of Agriculture which was organized in 1913, the cotton worm, boll worm and locust campaigns are carried out by the Administrative Division independently of the Entomological Section. The Entomological Section is part of the Technical Division of the Ministry of Agriculture. The Consulting Agriculturist, Mr. G. C. Dudgeon, who is also an entomologist, is head of the Technical Division. The Director of the Entomological Section is Dr. Lewis H. Gough, who is assisted by Messrs. G. Storey and E. W. Adair. In addition a staff of Egyptians under Dr. Gough's direction has charge of the inspection and fumigation of imported plants, which are treated at the port of entry. The fumigation of citrus trees, with a view to controlling *Aspidiotus aonidum*, which is a severe pest of oranges in the Delta region, is carried on by the Government fumigation brigades. Among the tropical fruit pests may be mentioned the pyralid moth *Ephestia cautella*, which seriously injures dates in some sections, and the butterfly *Virachola livia*, which attacks pomegranites.

In Egypt one meets in a striking manner the difficulties which confront the entomologist who has to deal in tropical countries with native agricultural labourers. These difficulties necessitate the control of insects, as far as possible, without the use of poisons or spray pumps. The native agricultural labourer is very ignorant and very careless and cannot be entrusted with poisons or with machines that are not entirely fool-proof. This accounts for the manner in which the annual campaign against the pests of cotton, the cotton worm and the boll worm is conducted by the Administrative Division. The regulations governing these campaigns provide for the hand-picking of the egg masses of *Prodenia litura* on the cotton leaves, and the reduction of the numbers of the boll worms is attempted by ordering and enforcing the destruction of all cotton bolls at a certain date each year after the final picking. Incidentally, it may be mentioned that persons who have been imprisoned for contravening the cotton worm laws are condemned to carry out these control measures. The pink boll worm of cotton *Gelechia gossypiella* was introduced into Egypt a few years ago with disastrous results, and methods for the control of the *Gelechia* larvae in cotton seed on a commercial scale are now being investigated; at present the treatment of seed, the destruction during the winter of cotton sticks and wood stored for fuel is required by law.

Reference should also be made to the work in Egypt of Mr. A. Andres, one of the inventors of the Andres-Maire bait traps for moths, to which reference is made in discussing the control of insects in India.

Sudan. The entomological work for this country is carried on by Mr. H. H. King, who is Entomologist to the Gordon Memorial College at Khartoum, the seat of Government. Mr. King's work has been largely confined to the study of the blood-sucking insects which are naturally of paramount importance in that region and his investigations on mosquitoes, and particularly on Tabanidae are furnishing valuable results.

In passing attention should be called to regulations governing the examination of persons entering the Sudan from Uganda for sleeping sickness. Such persons must proceed to Mongalla for examination by the Medical Officer there. There are also restrictions on trade with Uganda; it may only be carried on by licensed persons.

Locust outbreaks constitute a serious trouble from time to time in the Sudan, *S. perigrina* being the chief species and the use of poisoned bait, poisoned with sodium arsenite has been employed with success.

British West Africa. The British territories consist of the colonies of Gambia, Sierra Leone, the Gold Coast, Lagos, and Northern and Southern Nigeria. In these rich tropical regions the agricultural products are very varied, including not only such native products as rubber, palm oil, cacao and various native nuts, etc., but cultivated crops such as cotton, the development of which industry is progressing, rice, coffee, and corn (maize). The greatest obstacle to agricultural development under European direction has been the widespread occurrence of malaria, which for many years rendered permanent residence impossible to Europeans. To a lesser degree other tropical diseases contributed to the difficulties of existence and agricultural expansion. Fortunately, it has been possible in recent years by the adoption of the necessary anti-malarial measures to remove to an encouraging degree so serious an obstacle, with consequent impetus to the development of those rich territories.

The development of entomological work, in so far as it relates to the study and control of insect pests affecting the crops that are grown, has naturally been seriously handicapped by hitherto well nigh insuperable factors. Nevertheless, much pioneer work has been accomplished and a considerable amount of information has been collected regarding the insect pests occurring in the various territories. Mr. A. D. Peacock, late Entomologist for Southern Nigeria, has published an extensive report on the insect pests of that region and Mr. W. H. Patterson on the Gold Coast and Mr. A. W. Jobbins-Pomeroy in Nigeria, are prosecuting their investigations with a zeal that is not checked by the primitive and backward conditions of native agriculture, the difficulties of travel or the inadequacy of laboratory accommodation, assistance or entomological equipment. To those entomologists brought up and accustomed to work in the lap of luxury so far as facilities and apparatus for entomological investigations are concerned, the difficulties with which the British entomologists working in these tropical colonies have to contend are inconceivable. That they are able to accomplish so much is proof of their intense enthusiasm for their work and their ability to withstand conditions and surmount obstacles which would conquer any but the strongest natures.

The widespread prevalence of tropical diseases, particularly malaria and human Trypanosomiasis, led the Imperial Bureau of Entomology to undertake extensive surveys of the distribution of the blood-sucking insects of West Africa and Dr. J. J. Simpson has been conducting such an investigation. He has collected an enormous amount of valuable data and has made observations of great importance as a perusal of his numerous excellent reports which have been published in the *Bulletin of Entomological Research* will show. His investigations which are being continued at the present time constitute one of the most important phases of the Imperial Bureau's work.

AUSTRALIA.

A visitor to Australia is impressed with the abundance of insect life, particularly in the tropical and sub-tropical regions of the continent and, while little more than the fringe of the possible agricultural regions of the country has been utilized, if we except the sheep grazing sections, where production of deciduous and citrus fruits and sugar is being actively developed, the inevitable disturbance of the natural equilibrium and the introduction of new pests before quarantine restrictions are imposed, has followed. Fortunately, the continent appears to be well supplied with natural means of control of a vigorous kind, particularly as regards predatory insects such as ants and coccinellids, in fact Australia has always been the happy hunting ground for the lady-bird hunters.

The Commonwealth Government of Australia did not on its formation about fifteen years ago, assume any jurisdiction over agricultural matters, but left the individual states in full control. There is, therefore, no entomological work undertaken by the Commonwealth Government beyond the administration of the Federal Quarantine Act, which regulates the importation of plants, etc., into the country; this Act, I believe, is administered by the Department of Trade and Custom. As the entomological work is carried on by the various States independently it must be so described.

New South Wales. Agriculture is one of the principal industries of the State, the largest area being devoted to sheep grazing. Cereals, corn, tobacco, deciduous and citrus fruits and sugar cane are also grown successfully. Consequently the range of insect pests encountered in the State is extensive. The work of Mr. Walter W. Froggatt, the Government Entomologist is well-known. While his sphere is New South Wales, he carries on extensive correspondence with other parts of Australia, with New Guinea, Fiji and other islands of the Pacific. His experimental work is carried on at the various Experiment Farms in the State and at a small station at Narara experiments on the control of fruit flies, which constitute perhaps the worst insect pest on the continent, are conducted. Owing to the serious losses inflicted by various species of blowflies of the genus *Calliphora* on the sheep industry a special field station has been maintained for several seasons for the investigation of sheep maggot flies.

Under the State Vine and Vegetation diseases Act a large staff of inspectors is employed in different districts to see that the regulations concerning spraying, etc., are carried out. Imported fresh and dried fruits, seeds, etc., are subject to inspection and exported fruit is fumigated if required. An unusual line of work consists in the certification of freedom from the fowl tick (*Argas persicae*) of all the poultry going out of the State.

Under the direction of Dr. Frank Tidswell, Director of the Government Bureau of Microbiology, attention has been paid to insects concerned in the transmission of disease, particularly by Dr. J. B. Cleland, the results of whose investigations have been published in the Annual Reports of the Bureau.

Victoria. Agriculture in the State is of a general character, the area under cultivation, particularly in cereals, is increasing. Mr. C. French, Jr., is responsible for the entomological work, but little work of an investigatory character appears to be carried on. A large part of Mr. French's time is devoted to the administration of the Fruit and Nursery Inspection ordinances.

South Australia. About two thirds of the area of the State are farmed or grazed. The climate permits the growing of citrus fruits, almonds and olives and there is a considerable acreage under vineyards. The entomological work of the State is carried on by the Horticultural Division of the State Department of Agriculture at Adelaide. Strict measures are employed to prevent the introduction of the grape phylloxera and of other exotic insect pests by the usual methods of fumigation, etc. Nursery inspectors are also employed to carry on a campaign against the codling moth and scale insects affecting fruit.

Queensland. The State Department of Agriculture has maintained an Entomologist since 1897 and the name of the Government Entomologist, Mr. Henry Tryon, who has his headquarters at Brisbane, is known to most entomologists. The varied climatic conditions of the State permit the existence of an extensive range of insect pests, affecting in addition to the usual agricultural crops and fruits, such tropical and subtropical crops as cotton, sugar, pineapples, bananas, coconuts and coffee. Mr. Tryon has recently returned from a world's tour taken for the purpose of investigating the methods by which the prickly pear may be destroyed. Much of the Entomologist's time is occupied in travelling about the State. Insects affecting sugar cane receive, perhaps, the most attention, a special field station for their investigation being maintained at Gordonvale, near Cairns. In the sugar-cane growing district Grub Pest Destruction Committees exist for the purpose of encouraging the destruction of sugar-cane insects, particularly the beetle *Lepidoderma albohurtum.*

Imported and exported fruits and fruit grown and sold in the State are inspected under State regulations by a staff of inspectors and the inspection of nurseries is also carried out.

The existence of insect borne diseases in the State has resulted in attention being paid to this branch of entomology and at the Tropical School of Medicine at Townsville Mr. F. Taylor has carried on some excellent work on blood-sucking Diptera, particularly *Culicidae* and *Tabanidae.*

Tasmania. The entomological work of the Island State is conducted in conjunction with the phytopathological work and advice on the control of insect pests is also given by the Fruit Expert. Imported fruit is inspected and local Fruit Boards administer the provisions of the Codling Moth Act.

Western Australia. The agricultural productions of this State whose cultivated lands fringe the western coast of the continent consist mainly of cereals, fruit and wines. Large areas suitable for the cultivation of the vine, olive and silk could be opened up if labour and means of transport were procurable. An Entomologist has been maintained since 1898 and the present occupant of the position is Mr. J. L. Norman, with headquarters at Perth. An inspection service is maintained for the supervision of imported vegetation and the nurseries in this State, and modern methods of dealing with insect pests affecting fruit are very generally followed.

Northern Territory. Little work on economic insects has been carried out in the State owing no doubt to the lack of agricultural development. But the Government Entomologist, Mr. Gerald F. Hill, who is stationed at Darwin, has made some valuable and interesting contributions to our knowledge of the Termites. Recently he has been studying the relation of blood-sucking flies to the transmission of parasitic nematode worms, and he will no doubt have excellent opportunities for further work on veterinary and medical entomology.

CANADA.

The interest in each other's work and the spirit of co-operation that exists between Canada and the United States renders an enumeration of our entomological problems unnecessary, for owing to the fact that we share the same continental area without any barrier greater than a parallel of latitude and a few rivers and lakes we are compelled to experience many of your entomological troubles and to receive the generous overflow your hospitality to foreign invaders provides. But while we may have to study the control of the same insects that occur in the United States, it does not necessarily follow that our methods will be the same. In many cases the environmental conditions in Canada, particularly in the matter of climate, are different with a resultant difference in insect behaviour and therefore in control. Accordingly, in our entomological work we are taking nothing for granted, except where we are compelled, but we are working out our own problems *de novo*.

While applied entomology was officially recognized in Canada as early as 1856 it did not have its real birth until 1869, six years after the establishment of the Canadian Entomological Society, now the Entomological Society of Ontario by reason of a provincial grant and charter. The recognition and support of this Society by the Province of Ontario constituted the only official step in applied entomology until the appointment of Dr. James Fletcher by the Dominion Government in 1884 as Government Entomologist. The Dominion Experimental Farms were established in 1886 and to this Branch of the Department Dr. Fletcher was attached as Entomologist and Botanist until his death in 1908. A separate Division of Entomology of the Experimental Farms Branch was then created and I was entrusted with the organization on my appointment in 1909 as Dominion Entomologist. In 1910 the Destructive Insect and Pest Act was passed and in 1911 the first Dominion Field Laboratory was established; these two facts are indicative of the two chief lines of the Dominion work—administrative and investigatory—and the development of the work along these special lines led in 1914 to the separation of the entomological service from the Experimental Farms Branch and its elevation to the status of an independent Branch of the Department of Agriculture. The sanction of the Dominion Parliament to increased appropriations which are now more in accord with the needs of the country is encouraging evidence of a desire to afford the means whereby the entomological service of the Dominion shall be in a better position to meet the requirements of the situation.

We have now nine field laboratories and two sub-stations. The laboratory at Annapolis Royal, N. S., serves as headquarters for the control work and bionomical studies of the brown-tail moth. Mr. G. E. Sanders, the officer in charge, is also investigating the bud-moths and green-fruit worms of apple and their control and is conducting insecticidal investigations. A sub-station is situated at Bridgetown, N. S., at present.

A new and commodious laboratory building in Fredericton, N. B., serves as headquarters for the work in New Brunswick, of which Mr. J. D. Tothill and Mr. L. S. McLaine have charge. Mr. Tothill is in charge of the colonization of the parasites and predatory enemies of the brown-tail and gipsy moths which enemies, through the courteous co-operation of Dr. L. O. Howard, Chief of the United States Bureau of Entomology, we are collecting and importing from the New England States. In addition Mr. Tothill is conducting an intensive study of the natural control of three of our widely spread and periodically destructive insects—the tent caterpillar (*Malacosoma disstria*) the spruce budworm (*Harmologa fumiferana*) and the fall webworm (*Hyphantria cunea*). It is our intention to continue this study over a number of years. The results secured during the past two or three years have indicated the value and necessity of such an intensive study. Mr. McLaine has charge of the field work against the brown-tail moth in the winter on which a force of seventeen to twenty inspectors is engaged, and in the summer he is stationed with two assistants at the Gipsy Moth Laboratory, Melrose Highlands, Mass., in connection with the breeding of the parasites of the brown-tail and gipsy moths.

At a field laboratory situated at Hemmingford, Quebec, a little south of Montreal, Mr. C. E. Petch is investigating the apple and plum curculios, and other insects affecting apple in connection with which experimental and demonstrative work on spraying is conducted in a number of orchards. Mr. Petch has also been carrying on experiments for three seasons on the control of locusts by means of the *Coccobacillus acridiorum*.

There are two Field Laboratories in Ontario. At Vineland in the Niagara fruit district, Mr. W. A. Ross is in charge of a laboratory where fruit insect investigations are mainly carried on. For four seasons Mr. Ross has been studying the control of the apple maggot (*Rhagoletis pomonella*). Two years ago he commenced an investigation of the aphids affecting apple: *Aphis sorbi*, *A. pomi* and *A. avenæ*, which are very injurious. Greenhouse and mill-infesting insects are also studied at this laboratory. At a laboratory at Strathroy, Ont., in the western part of the province, Mr. H. F. Hudson, who is at present on leave in Flanders, has investigated the chinch bug (*Blissus leucopterus*) and commenced a study of the white grubs (*Lachnosterna* spp.) which investigation is being continued in his absence by Mr. J. R. Gareau.

Our next Field Laboratory is situated at Treesbank in southern Manitoba and here Mr. Norman Criddle, whose work on locust control is well known, is investigating the bionomics and control of white grubs (*Lachnosterna* spp.) and in this connection I should mention that this investigation is complementary to that now being conducted by the United States Bureau of Entomology, the intention being to study these insects over the whole range of their distribution in North America. The value of such co-operative inquiry is obvious to all. In addition Mr. Criddle is investigating the insects affecting cereals and the results of his studies of the Hessian fly and the wheat-stem sawfly have been recently published.

The prairie region is also served by a laboratory at Lethbridge in southern Alberta where Mr. E. H. Strickland has been devoting particular attention to a study of the various species of cutworms which are seriously injurious to grain and other crops periodically. For example, in 1912 *Porosagrotis orthogonia* destroyed about 35,000 acres of wheat. Last year the Army Cutworm (*Chorizagrotis auxiliaris*) was studied and control measures were demonstrated in the field with valuable results. Mr. Strickland has also been investigating the abundant nematode fauna associated with growing grain.

The headquarters for our work in British Columbia are at Agassiz in the lower valley of the Frazer River. Mr. R. C. Treherne, the officer in charge, has been investigating both fruit insects and insects affecting vegetable crops. The results of his study of the strawberry root weevil (*Otiorynchus ovatus*) were published some time ago and his investigations on the cabbage root maggots are now completed. In addition he has made valuable observations as a base for further study, on the wheat midge (*Diplosis ? tritici*) and the budmoth of apple and other apple insects.

At Vancouver, B. C., we have a laboratory for forest insect investigations. Mr. R. N. Chrystal, the field officer in charge, has been studying in particular the insects destroying conifers in Stanley Park, especially species of *Chermes* and one or two lepidopterous larvæ. Under the direction of Mr. Swaine he has continued the latter's observations on the *Scolytidæ* and other timber destroying beetles in the province.

All the work is directed from Ottawa where the offices of the Entomological Branch are situated. Mr. Arthur Gibson is Chief Assistant Entomologist and in addition to assisting in the regular executive work of the Branch and the administration of the provisions of the Destructive Insect and Pest Act, he has charge of the work on insects affecting field crops, garden and greenhouse and stored products. Mr. Gibson's work on the Noctuidae is well known and during the last few years he has been investigating chiefly the control of locusts and root maggots. Mr. J. M. Swaine is Assistant Entomologist in charge of Forest Insect Investigations. The extensive coniferous forests of Canada naturally offer great opportunities for such investigatory work and particular attention has been paid to serious and widespread injuries by Scolytid beetles in British Columbia. For a number of years Mr. Swaine has been making taxonomic and biological studies of the *Scolytidae* and we hope to commence the publication of the results of this study shortly. Our studies of the spruce budworm, exclusive of its natural control, have been completed and in addition much ground work has been accomplished in the study of insects affecting shade trees. Mr. Germain Beaulieu has charge of the collections and the recent establishment of a national collection of insects has enabled us to give this aspect of our work the recognition it deserves.

The Dominion work of preventing the introduction and spread of injurious insects is carried on under the Destructive Insect and Pest Act, 1910. Under the Regulations of this Act the importation of all nursery stock, etc., is governed. Nursery stock may be imported only during certain periods through prescribed ports of entry at which fumigation and inspection stations are provided. Importers are required to give notice of the ordering and receipt of those classes of trees and plants subject to inspection. Quarantine regulations also prohibit the importation of certain classes of nursery stock and vegetable products, for example, the importation of conifers and evergreens from the New England States is prohibited on account of the gipsy moth, of potatoes from California on account of the potato tuber moth (*Phthorimaea operculella*), of non-canned fruit from the Hawaiian Islands on account of the Mediterranean fruit fly (*Ceratitis capitata*). The field work against the brown-tail moth in Nova Scotia and New Brunswick is also carried out under the regulations of this Act. Each winter the whole of the infested area in these two provinces is scouted and all the winter webs of the brown-tail moth are collected. This careful work has so far prevented the establishment of this insect in New Brunswick and has kept it from increasing beyond harmless proportions in Nova Scotia.

It would exceed the limits which must necessarily be set to an account of this nature if I permitted my enthusiasm to exceed my judgment and described further aspects of our work which are reported annually, although I am aware of the humiliating fate that annual reports not infrequently suffer.

Mention should be made of the valuable investigations that are being carried on at Agassiz, B. C., by Dr. Seymour Hadwen, Assistant Pathologist of the Health of Animals Branch of the Dominion Department of Agriculture, on the life histories of *Hypoderma bovis* and *H. lineata*, which are undoubtedly the most important hitherto carried out.

In certain of the provinces applied entomology has made encouraging progress, particularly during the last few years. In Ontario, in which province applied entomology in Canada had its birth, the Entomological Department of the Ontario Agricultural College at Guelph has always combined with its educational work the duty of assisting the farmers and fruit growers of the province in solving their problems and with this work and the earlier work in Canada the name of Dr. C. J. S. Bethune will always be associated. In 1912, Mr. Lawson Caesar, who is Associate Professor of Entomology in the Agricultural College, was appointed Provincial Entomologist. In addition to the investigatory work on insects affecting fruit, Prof. Caesar has charge of the inspection of nurseries in Ontario, which work is carried out under the provincial Fruit Pest Act.

British Columbia at present has no Provincial Entomologist owing to the removal of Mr. W. H. Brittain, the occupant of that position for one year, to Nova Scotia. Mr. Thomas Cunningham, the Provincial Inspector of Fruit Pests has charge of the work involved in administering the regulations of the Provincial Horticultural Board governing the control of insect pests and plant diseases. It is largely due to his zeal that the province is so remarkably free from such orchard pests as the San Jose scale and codling moth. The inspection of foreign nursery stock is carried out by a co-operative arrangement with the Dominion Department of Agriculture.

The Province of Nova Scotia appointed a Provincial Entomologist in 1912, Dr. R. Matheson being the first officer. He was succeeded in 1913 by Prof. W. H. Brittain, who is also Professor of Entomology in the provincial Agricultural College at Truro, N. S. In addition to administering the provincial Injurious Insect and Pest Act, and his teaching duties, Prof. Brittain has found time to initiate several important entomological inquiries. In particular may be mentioned investigations on the aphids affecting apple, the apple maggot and *Lygus invitus*. For the purpose of prosecuting this work two provincial field laboratories have been provided, one at Kentville N. S., and the other at Smith's Cove, N. S. All nursery stock entering the province is inspected and fumigated and the Dominion Department of Agriculture has agreed to the inspection and fumigation by the province of foreign nursery stock.

Since the establishment in the province of Quebec of the Macdonald Agricultural College at St. Annes in 1907, Prof. W. Lochhead and his staff have developed the study and practice of applied entomology in the province and at the present time entomological investigations are being conducted there. Much educational work is being accomplished through the Quebec Society for the Protection of Plants from Insect Pests and Fungous Diseases which receives a provincial grant. In 1912 the Abbe V. A. Huard, Curator of the Provincial Museum at Quebec, was appointed Provincial Entomologist and he administers a provincial act passed in 1913, providing for the inspection of nurseries in the province.

In the other provinces of Canada, no provincial entomologists have been appointed and where entomological investigations are being conducted they are in connection with one or other of the Dominion Field Laboratories that I have mentioned. As the need for more work, particularly of a local character, develops, additional attention will no doubt be paid by the Provincial Departments of Agriculture to applied entomology. In the meantime they rely on the assistance provided by the Dominion Government. Where Dominion and provincial officers are carrying on investigations in the same province, the heartiest co-operation is enjoyed and arrangements are made with a view to preventing duplication of the work and consequent loss of energy. In certain cases investigations are conducted conjointly and this spirit of co-operation is most valuable, particularly in its relation to the attitude of the public towards the work.

CEYLON.

For a number of years Mr. E. E. Green, who is widely known by his work on the Scale Insects, was Government Entomologist to the Department of Agriculture of Ceylon and subsequent to his relinquishing the position in 1911, entomological work on this island was carried on by Mr. A. Rutherford whose recent untimely death was a great loss to colonial entomology. Mr. E. R. Speyer is now in Ceylon investigating the most serious insect pest of the island, namely, the shot-hole borer of tea *Xyleborus fornicatus*. Tea is also injured by the tea Tortrix, *Capua coffearia*, the yellow tea mite, *Tarsonemus translucens*, and the Termite, *Calotermes militaris*, which hollows out the stems of living tea bushes. Rubber in Ceylon is attacked by a number of insects, particularly root and other borers. Cocoa, rice and mulberry plants are subject to the attacks of a number of pests. Various species of Termites are injurious to woodwork as in most tropical countries where they occur.

FIJI.

When Mr. F. P. Jepson commenced his work as Entomologist to the Department of Agriculture of Fiji in 1909, he found serious problems awaiting his attention, particularly in the matter of insects affecting bananas and cocoanuts. On the island of Viti Levu cocoanut cultivation was practically abandoned many years ago, owing to the injury done to the leaves by a small moth *Levuana iridescens* B. B. Since 1912 a change has taken place which renders the chances of combatting the insect successfully more hopeful. The most serious pest of the bananas in Fiji is the weevil *Cosmopolites sordidus* Germ.; as many as 100,000 individuals having been collected in one month on a single plantation. This widely distributed pest was introduced in 1901. As enemies in the form of predacious beetle larva occur in Java and Dutch Borneo, and in view of the impossibility of controlling the pest by artificial means, Mr. Jepson visited Java in 1913 to study the insect predators of this weevil and among them he found the Histerid beetle, *Plœsius javanus* Er., the most effective. Five thousand of these beetles were collected and three thousand seven hundred and ninety-two were successfully transported to Fiji where they were distributed in lots of 500 upon different badly infested banana plantations. Subsequent visits showed that the beetles were alive and reproducing after four months in the country and good results are expected from this interesting experiment, which indicates the progressive character of Mr. Jepson's work.

INDIA.

The control of insect pests in India is a subject of singular interest, not so much on account of the unusual nature of the insects which are encountered there but owing chiefly to the character of the cultivators, the nature of the country and the climatic conditions. Agriculture constitutes at present the chief industry of the country and about sixty-five per cent. of the people are dependent upon it as a means of livelihood. The European planter is practically negligible as a constituent factor, the dominant class being the cultivators. These are native Indians who live on the land and have had a very limited education. In many cases they have inherited a perfect system of agriculture. But in the face of an insect outbreak their preconceived notions of such calamities, their aversion to taking life directly and their lack of any kind of material equipment for fighting pests make the application of modern methods of insect control almost an impossibility. Prof. Maxwell Lefroy who did valuable work of a fundamental character in India, has described some of the prevalent ideas, he says: "An intelligent cultivator growing sugar-cane under irrigation on an extremely sound system with good manure, believes the cane-borer comes with the well-water used for irrigation." He has no conception of its life history but he regards the whole thing as a mystery, not comparable with the life of any other animal; he will, as likely as not, call in a priest to check it; the priest will perhaps write four texts from holy writings, place them one at each corner of the field to confine the evil influence and then remove one to let out the influence which the texts have incommoded. Or, he will pay a man of a certain caste to plough a line across the field at night, the man having to be stark naked. In some parts locusts are believed to be the incarnation of a particular deity and for each one killed a hundred will come; it is quite likely that this has occurred, of which a few were killed being followed later by a much larger swarm, but where we see no connection, he sees a definite sequence of events. A case came up where a man freed his rice field of a pest by a simple mechanical method; his crop benefited but soon after his cow died, and to that village the one was a consequence of the other. It is difficult for entomologists in countries such as ours to realize the almost impossible task of overcoming such long inherited and deeply ingrained instincts and religious beliefs. These facts should be borne in mind in studying the methods employed. The use of insecticides is naturally enormously restricted as also is the employment of any but the simplest of mechanical devices. Largely for these reasons we find the necessity of resorting to such methods as the use of bait traps for moths and hand picking, the latter being rendered possible by the cheapness of the labor.

The losses from insects in so large a country are naturally great and in many instances the failure to grow staple crops in certain regions is undoubtedly due to an inherited tradition, resulting from uncontrolled insect outbreaks, that such crops cannot be grown. An outbreak of the cotton boll worm in the Punjab and Sind in 1906–07 caused a loss of about 2,000,000 pounds sterling. In the locust campaign of 1903–04, 14,000 pounds sterling was spent in destroying these insects in one province. The great Kirman Desert of Persia constitutes the chief central breeding place for the parent flights of *S. peregrinum*, entering India from the northwest.

In order to understand the organization of the work in applied entomology it is necessary to know the system of government. The government of India is the supreme authority, the provinces into which the country is divided being under provincial departments such as Madras, Bombay, Central Province, Bengal, etc. The Imperial Department of Agriculture conducts investigations and advises and directs the work of the provincial departments. The latter largely carry into effect the recommendations of the Imperial experts as they do not all employ experts of their own, although a number of them now have native or European entomologists attached to their agricultural staffs.

The headquarters of the Imperial Entomologist are at the Imperial Research Laboratories at Pusa. Mr. T. Bainbrigge Fletcher is Imperial Entomologist and Mr. T. M. Howlett has charge of the work in medical and veterinary entomology. In addition to English assistants there is an excellent native staff. The scope of the work includes the investigation of the life histories and bionomics of insect pests and the most practicable methods of control under local conditions and experimental work with insecticides.

An important section of the entomological work has reference to useful or productive insects particularly sericulture and the production of lac. These constitute important industries in certain sections of India. For example, about three million pounds worth of lac is produced annually and whereas at present it is mainly a forest product, collected wild in the jungles, the entomologists have shown how it can be produced more cheaply by proper cultivation on trees growing on pastures and waste lands in agricultural tracts. Prof. Lefroy's work on Eri silk, produced by *Attacus ricini* of Assam, furnished a means whereby a new silk industry might be built up in certain localities in India.

Among the more important pests the following may be mentioned:

In certain regions swarms of hairy caterpillars, the larvæ of Arctiid moths, appear regularly after the first rain and cause great loss in grass lands, etc. It has been found that these insects can be largely controlled by capturing the adult moths in bait traps of the Andres-Maire pattern. In one region in Bengal about 10,000 acres of Tal land was destroyed annually for fifteen years by caterpillars of *Agrotis ypsilon*. It was found that hand picking of the larvæ and capture of the moths by bait traps constituted the best control measures. In the bait traps eighty per cent. of the moths were unfertilized females. Serious damage to the rice crop is caused by the rice grasshopper (*Hieroglyphus furcifer*). For the control of this insect coarse bags are used, the bags being kept open by two bamboos as they are drawn through the rice which of course is grown in water; two beaters go before the bag and drive the grasshoppers towards or with it. Cotton is attacked by two boll-worms and a *Gelechia;* the boll-worm is a serious bar to the growth in India of any but the short stapled cottons which mature rapidly and offer little scope for boll-worm injury. In the control of the boll-worm in the Punjab, success appears to have attended the use of parasites.

The immense loss of life due to insect-borne diseases, especially to malaria in India is well known and the importance of the work carried out by Mr. Howlett in conjunction with the Imperial Medical and Veterinary Departments needs no emphasizing. Entomologists and medical men in India have had no small share in the advancement of our knowledge of medical entomology from the time when Ross carried out his crucial investigations up to the present time and the standard and scope of the work in India is steadily increasing year by year through the labors of men such as Dr. W. S. Patton, F. W. Cragg and others.

The condition of India in regard to that problem, which is of such vital concern to more temperate regions and regions in which agricultural development is taking place, such as the United States and Canada, namely, the introduction and establishment of foreign insect pests is peculiar and full of interest from a biological standpoint. The fact that India has not taken in years past any special steps to prevent the introduction of insect pests may appear strange to the minds of many accustomed to the necessity of such measures. The omission is not due to a failure to appreciate the importance of foreign pests, but to a distinct failure on the part of foreign pests to become acclimatised to Indian conditions. India appears to be protected far more effectively, and at considerably less cost, against foreign insect pests by her climate and topographical features. It is an isolated country bounded on the north by a vast non-agricultural territory from which it is separated by a formidable mountain barrier. Prof. Lefroy informs us that in India fierce dry heat is the insect's enemy and the greatest check on insect life is that period before the rains when all is parched and very hot. These are powerful adverse factors to most foreign insects, although some, such as the cabbage white (*Pieris brassicæ*) and the wheat aphis (*Toxoptera graminum*) have adapted themselves in different ways to the climatic conditions. A statement which Prof. Lefroy has given of the relative proportions of native and introduced insects indicates very clearly the evident check on the ability of foreign insects to become acclimatised to India. Of the crop pests, exclusive of scale insects and mealy bugs, out of 213 species injurious in some degree, two moths and six aphides are possible introductions. Out of 109 scale insects, 24 are probably introduced and of the most injurious ones, eleven out of the fourteen, are introduced; the introduced scale insects are comparatively harmless as a rule in India. These facts afford an interesting contrast to our experience in North America.

NEW ZEALAND.

The chief agricultural industry in New Zealand has been sheep farming. But with development along other lines, particularly in horticulture, the country has suffered the fate of all new countries dependent upon the importation of plants from foreign countries, and foreign pests have been introduced. At first these pests were not subjected to the methods that a later developed intensive system of agriculture involves and consequently they made some headway.

While the entomological work of the government is largely undertaken by the Government Biologist, Prof. T. W. Kirk, the question of the control of insect pests is also dealt with by the Fields and Experimental Farms Division and by the Orchards, Garden and Apiaries Division. The latter Division administers the inspection laws, involving the fumigation and inspection of imported fruits and plants and the spreading of useful insects. The Biological Section of the Department of Agriculture investigates, so far as its other duties permit, injurious insects in addition to conducting general identification work.

BRITISH WEST INDIES.

In 1898 the Imperial Department of Agriculture for the West Indies was established with headquarters at Barbados for the purpose of rendering assistance in agricultural matters throughout the British West Indies, including British Guiana, Trinidad, Jamaica, British Honduras, Bahamas, Bermuda, Barbados, the Windward Islands and the Leeward Islands. It is principally concerned, however, with the smaller islands, namely, those of the Windward and Leeward groups and Barbados. As the larger colonies British Guiana, Trinidad and Jamaica have organized departments of agriculture and being in a more prosperous condition, it is the function of the Imperial Department to advise the Government of these colonies. In the case of British Honduras, Bahamas and Bermuda, advice by correspondence is fully available.

Mr. H. A. Ballou succeeded Mr. H. M. Lefroy in 1903 as Entomologist on the staff of the Imperial Department and he carries on his work under the direction of the Commissioner of Agriculture, Dr. Francis Watts. In addition to the entomological work conducted by the Imperial Department, certain of the West Indian colonies maintain entomologists or combine the work with that on plant diseases. Mr. F. W. Urich is Entomologist to the Board of Agriculture for Trinidad and Tobago; Mr. G. E. Bodkin, as Economic Entomologist to the Department of Science and Agriculture of British Guiana, is responsible for the entomological work in that colony. Mr. A. H. Ritchie was appointed about a year ago as Entomologist to the Department of Agriculture for Jamaica. In Barbados the entomological work of the island is carried on by Mr. J. S. Dash, the Assistant Superintendent of the local Department of Agriculture, for although the Imperial Department of Agriculture has its headquarters in Barbados it has no direct connection with the agriculture of the colony.

The Entomologist of the Imperial Department of Agriculture Mr. Ballou, is directly concerned with the insect problems of the Windward Islands (Grenada, St. Vincent and St. Lucia) and the Leeward Islands (Dominica, Montserrat, Antigua, St. Kitts-Nevis and the Virgin Islands). He has a laboratory in the departmental building and on each island facilities for field work are provided by the local agricultural departments, each of which has a botanic garden or experiment station, and the officers in charge of these gardens or stations assist in the local entomological work.

The chief lines of entomological investiagtion are associated with the principal crops grown on the islands, namely, sugar cane, cotton, cacao, limes and cocoanuts. A large number of new crops are being tried and these will naturally introduce new lines of entomological inquiry. The islands have suffered the fate of all new regions into which new crops have been introduced. The crops grown at present are practically the same as they were ten years ago, the principal difference being the standing of the cotton industry which was then in an experimental stage. Now it has been established as a profitable industry and as a result of the rapid increase in the acreage of cotton, insects which previously were not recognized as pests, and in some cases were unknown to science, have assumed an important role as serious pests. For example, the flower-bud maggot of cotton (*Contarinia gossypii* Felt) first made its appearance in Antigua in 1907; the leaf blister mite *Eriophyes gossypii* Banks, first occurred as a pest of cultivated cotton in Montserrat in 1903 and soon afterwards was found in all the other islands of the Leeward and Windward groups. The black scale (*Saissetia nigra* Nietn.) was formerly a serious pest of cotton, but at present it attracts little attention owing to the control brought about by the parasite (*Zalophothrix mirum*) which was first reared in 1907. Important injuries are caused by certain hemipterous cotton stainers of the genus *Dysdercus*, and a serious internal boll disease or rot now under investigation, occurring in certain islands appears to be associated with the attacks of these cotton stainers.

One of the most serious classes of injurious insects occurring in the West Indies, particularly in fields of sugar cane and corn (maize), are the Melolonthid larvæ known as white grubs on this Continent; these insects are popularly known as hard backs on the islands, the chief species being *Ligyrus tumulosus*. On certain of the islands recent investigation has shown that a noticeable control is exercised by several insect parasites of these larvæ. Among the control measures recommended are the planting of trap crops and hand picking the larvæ which measure cheap juvenile labor renders possible. Lepidopterous and rhyncophorous borers, particularly such root borers as *Diaprepes abbreviatus* L. and *Exophthalmus esuriens* are serious pests of sugar cane. Termites are also injurious to sugar cane.

Citrus trees in the West Indies have their full share of scale insects, the purple scale (*Lepidosaphes beckii* Newm.) being the most important. A considerable degree of control is exercised over this and other scale insects by certain entomophagous fungi. The red-headed fungus (*Sphærostilbe coccophila*) and the white headed fungus (*Ophionectria coccicola*) attack the purple scale, the former fungus also attacks the white fly (*Aleyrodes citri* R. and H.) The green scale (*Coccus viridis* Green) is controlled to a marked degree by the shield scale fungus (*Cephalosporium lecanii*). In Trinidad the fungus *Metarrhizium anisoplæ* has been artificially cultivated and used with a view to controlling frog-hoppers attacking sugar cane.

Naturally every effort is made to prevent the introduction of foreign pests into the islands by quarantine regulations. The regulations of the various plant quarantine acts are carried out by the local agricultural officers in the various islands; these officers are required to inspect plant imports and to arrange for the necessary fumigation and other prescribed treatment.

Much of the entomologist's time is occupied in traveling, owing to the geographical situation of the islands of the Lesser Antilles and the difficulties of steamboat travel which result in an unfortunate loss of time. Nevertheless, the pages of the *West Indian Bulletin*, the quarterly journal of the Imperial Department of Agriculture and its fortnightly publication, *The Agricultural News*, and the pamphlets that have been issued dealing with the insect pests of various crops bear witness to the excellent work that is accomplished by the Entomologist in spite of the difficulties with which he has to contend. And the same may be said of those who are responsible for entomological work in the individual West Indian colonies that I have mentioned.

OTHER IMPERIAL ENTOMOLOGICAL WORK.

Space forbids an individual treatment of the entomological work that is being carried out in scattered units of the British Empire to which reference has not been made. In many of these places the investigations that are being conducted relate chiefly to insects and ticks concerned in the transmission of disease such as those of Dr. W. M. Aders on ticks in Zanzibar. In the Seychelles entomological observations are being made by Mr. P. R. Dupont, the Curator of the Botanical Station; in the Federated Malay States Mr. C. Strickland is studying mosquitoes and malaria, and other entomological work, particularly on locusts, is also being carried on by Mr. C. B. Holman Hunt and Mr. P. B. Richards. M. D'Emmerez de Charmony is paying attention to the insects of Mauritius, and in Cyprus the entomological work is conducted by Mr. Z. G. Solomides, who is called upon to deal with the locust plagues to which this island is subject.

THE THORACIC AND CERVICAL SCLERITES OF INSECTS.

By J. F. Martin.*

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INTRODUCTION.

This paper is presented as the morphological part of a thesis for the degree of Doctor of Philosophy at the Massachusetts Agricultural College. It has been prepared under the supervision of Dr. H. T. Fernald and Dr. G. C. Crampton, to both of whom I wish to express my sincere thanks for the many ways in which they have guided and helped me in the work. I am also indebted to Dr. G. C. Crampton who has kindly furnished all the material upon which this paper is based and by which it was made possible.

Some of the literature used and referred to was obtained from the library of the Massachusetts Agricultural College. Other volumes were obtained from the Boston Society of Natural History, through Dr. H. T. Fernald. Most of the books, however, were loaned from the private libraries of Dr. C. H. Fernald, Dr. H. T. Fernald, and Dr. G. C. Crampton, to each of whom I am greatly indebted for their use.

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*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College.

The homologies of the thoracic sclerites have been greatly confused, owing to the fact that most investigators have given their own views, without first giving sufficient study to the work and terminology of previous writers. This has resulted in the invention of new terms and the misapplication of those already in use. Both the old and new terms have often been applied to identical sclerites and consequently the terminology is also in a chaotic condition.

Some of the more recent writers have attempted to show the unity of thoracic structure, which exists in all insects and to introduce a terminology which will be as uniform as possible. This is a very difficult task to accomplish because of the great confusion which exists.

In this paper an attempt is made to help straighten out the homologies and terminology of the thoracic sclerites of insects. An effort has been made as far as possible, to use the terminology most widely accepted and which has the right of priority. Where recent terms have been applied to sclerites, for which the old terms seem inadequate or undesirable, the new terms have been adopted. In some cases entirely new terms have been applied to sclerites, but only where the condition of the terminology seemed to warrant such action and where, in the opinion of the writer, an improvement could be made.

Especial attention has been given to a study of the pleuron and sternum. The tergum and wings have not been investigated so thoroughly and consequently a discussion of these parts is not given in detail. All the specimens were studied under a liquid medium (water, alcohol or glycerine), with the aid of a Zeiss binocular microscope. A bull's eye condenser was used to concentrate the rays of an electric light upon the object under study. In many cases the specimens were first boiled in 10% potassium hydroxide. The internal tissues were then washed out with running water, thereby making the sclerites show up clearly and leaving the internal processes intact. This procedure greatly facilitated the determination of the thoracic sclerites and their sutures.

HISTORICAL REVIEW.

Several theories have been proposed to explain the probable formation of the thoracic segments and almost every writer seems to have a different view of the subject. This has led to the formulation of many different theories, some of which are merely the unsupported statements of their respective authors, who have failed to give reasons for their views. Such theories apparently have no evidence to support their presentation and hence cannot be accepted, especially when other writers have advanced differing theories established upon firmer grounds. Some investigators have based their ideas of the thorax upon the study of a limited number of insects, whereas they should have studied at least a representative number from different groups, in order to obtain a general conception of the thorax. Others who have studied a large number of insects have failed to recognize the relation that exists between the thoracic sclerites. This has given rise to incorrect interpretations of the formation of the thorax and to great confusion in the homologies of the thoracic sclerites in the same and in different insects.

The earlier entomologists wrote very little about the insect thorax. Knoch, 1801, termed the prothorax "Collum" and the meso-, and metathorax, "Pectus." He may have recognized that the thorax was composed of three segments, which are topographically grouped into two parts, the collum and pectus, or he may have considered that the thorax was actually composed of only two segments, viz.: the collum and pectus.

Chabrier, '20, Kirby, '28, and later Verhoeff, '02–'04, although aware that the thorax was composed of at least three segments, thought that it might be divided according to function into two parts. These two parts were termed by Chabrier, the collier and tronc alifere; by Kirby, the manitruncus and alitruncus; and by Verhoeff, the proterothorax and deuterothorax. This idea is no longer accepted.

Audouin, '24, upon whose investigations the modern conception of the thorax is based, points out that it is composed of three simple segments and was the first to work out a terminology for the thoracic sclerites, which has been used by all subsequent entomologists. Beginning with the anterior thoracic segment, he named them the pro-, meso-, and metathorax, terms which seem to have been first used by Nitzsch, '18, although Nitzsch called the first segment the protothorax instead of prothorax. Audoiun regarded each thoracic segment as made up of four parts; a dorsal region, the tergum; a ventral region, the sternum; and two lateral regions, the pleuræ. He thought that the tergum was composed of four transverse subdivisions, lying one behind the other in consecutive order. Beginning with the anterior one, he termed these the prescutum, scutum, scutellum and postscutellum. The sternum he regarded as a single piece. For each lateral region or pleura he described and named several pieces, viz.: two large lateral sclerites, the anterior one termed the episternum and the posterior one the epimeron; a small narrow piece lying along the anterior edge of the episternum termed "paraptere," (previously called "hypotere" by Audouin, '20); a small sclerite containing the spiracle termed the peritreme and a sclerite articulating with the epimeron termed the trochantin.

Audouin was mistaken in his definition of the last mentioned sclerite, because the trochantin articulates with the episternum, not with the epimeron. Later Audouin, '32, defined the "paraptere" as "the small piece so visible in Hymenoptera and Lepidoptera, which covers the base of the fore wings and which is variously designated by the terms ecaille, epaullette or squamula." (Audouin's trans. of Mac Leay's paper, "The comparative anatomy of the thorax in winged insects, following a review of the actual state of the Nomenclature." pp. 41, footnote by Audouin). According to this statement the "paraptere" is evidently synonymous with tegula.

Subsequent entomologists in applying this terminology for the thoracic sclerites have misinterpreted the homologies and consequently confused the names. Several sclerites, which Audouin apparently failed to recognize, have since been described. In descriptions of these, different investigators have invented new terms for identical sclerites, leading to more confusion.

In all insects there is a common ground plan, which is more modified in some, less so in others. On this basis recent writers have attempted to work out a uniform system of terminology applicable to all insects. In order to do this, it is first necessary to correctly homologize the sclerites in the different orders of insects and then to straighten out the confused terminology which has been applied to them—an almost impossible task.

Straus-Durckheim, '28, believed that the thorax was composed of three segments and suggested that the cervical sclerites represent the remains of two segments, situated originally between the head and prothorax. This suggestion will be discussed under the heading, Cervical Sclerites.

Mac Leay, '30, considered that each thoracic segment was made up of four subsegments or annuli, represented in the tergum by the prescutum, scutum, scutellum and postscutellum. In the Zoological Jour. 1830, Vol. 5, pp. 160, he states that "owing to the development of the tergum, the pectus in Hymenoptera is exceedingly diminished. But were each of the sternums at its maximum of development, it would also be found to consist of four pieces like a tergum. This is the case in Julidae and is more or less apparent in Annulosa. For instance, the pectus of the prothorax in *Squilla* has a praesternum, sternum, sternellum and poststernum." Mac Leay leaves the pleuron out of consideration. According to modern ideas his view of the tergum is erroneous, since the tergum is made up of but two plates, as Verhoeff, '02, Snodgrass, '09, and others have proved. The anterior of these two plates is subdivided into regions by sutures, these regions being termed the prescutum, scutum and scutellum. The posterior plate is termed the postscutellum. Since Mac Leay claims that the four sternal plates described by him occur in the pectus of the Julidæ, which are diplopods, and in *Squilla*, which is a crustacean, his theory is not at all necessarily applicable to insects.

Newport, '39, evidently agreed with Mac Leay regarding the formation of the thoracic segments. He thought that each was made up of four subsegments or annuli, represented in the tergum by the prescutum, scutum, scutellum and postscutellum. These annuli, he thinks are partly fused in the pleural region and completely fused in the sternal region. Newport added nothing new to this theory of Mac Leay's and it must be regarded as untenable. Newport, however, brought forth a new view pertaining to the cervical sclerites, which will be referred to later. Furthermore, he is incorrect in his statement that Audouin considered each thoracic segment to be composed of four subsegments, for, as already stated, Audouin appears to have believed that the thorax consisted of three simple segments.

Schiodte, '56 and Winslow, '62, followed Audouin's ideas and believed that the thorax was composed of but three segments, the pro-, meso-, and metathorax.

Packard, '80, seems to have regarded the thorax as made up of three simple segments, but his interpretations and methods of homologizing the thoracic sclerites in the insects of the different orders which he studied, are incorrect. The homologies of the thoracic sclerites will be discussed further on.

Miall and Denny, '86, in their book on the Cockroach, considered that the thorax was composed of three segments and suggested that the chitinous plates at the base of each leg in the roach (i. e. epimeron, episternum, trochantin, etc.) represent "two basal leg joints, which have become adherent to the thorax," although in other cases they state that they belong "to the thorax and not to the leg."

If these sclerites at the base of the leg in the roach represent leg "joints," there would probably be more definite traces of these joints in other insects, especially as the leg is such an important appendage. In the embryo of the cockroach the coxa is apparently the only basal leg segment present and there are no indications of other leg segments which have or which might become adherent to the thorax. This is true for other insects as well as for larvae and primitive forms. Moreover, it is improbable that such leg segments, if present, would form the lateral wall of the segment or pleuron which Miall and Denny thought was the case in the Mole Cricket. It seems more probable that the basal leg "joints" or segments would remain in place and not move up into the pleural region. Börner considered the pleural plates as part of the sternum, but later with Henneguy, thought that they were plates of the basal leg segments.

Hagen, '89, advanced the theory that each thoracic segment was composed of three subsegments, each subsegment bearing a characteristic appendage. The anterior he terms the leg bearing, the next following the wing bearing, and the posterior, the spiracle bearing subsegment. Some of the subsegments develope more than others. On the prothorax of Strepsiptera and agrionids, he finds traces of "wings."

The spiracle does not occur in all the thoracic segments, being absent in some cases. Whether the spiracles which often occur between the thoracic segments belong to the immediate anterior or to the immediate posterior segment, is uncertain and at present a disputed question. What Hagen considered rudiments of wings on the prothorax of Strepsiptera and agrionids, have proved to be merely flaps and are no longer considered homologous with wings. Several fossil Palaeodictyoptera have a pair of lateral wing-like appendages on the prothorax, like rudimentary organs, but it is very uncertain whether these appendages do or do not represent traces of wings.

Patten, '90, claims that each thoracic segment is composed of two annuli. Using the nervous system of *Scolopendra* as a type, he found in all arthropods studied, two cross commissures in each neuromere, thus indicating the double nature of these structures. In *Acilius* the median furrow between the cross commissures was similar to that found between the successive neuromeres. In *Scorpio*, the neuromeres are distinctly double and in such forms as *Julus*, the cardiac ostia, arteries, tracheæ and legs show the double nature of the somites. Segmental fusion is also indicated by two pairs of tracheal invaginations in each segment of *Acilius*, by the bifurcated appendages of many crustacea and by the bifid maxillæ of insects, the latter group frequently having monsters with double pairs of legs.

Patten's double segment theory based upon the reasons cited above, does not coincide with the facts in all cases, and hence is open to objections. Furthermore, what occurs in *Scolopendra* should not be given too much weight, when considering the condition found in insects. In insects the last abdominal segment is considered as the fusion product of several neuromeres and yet it contains only two cross commissures, whereas according to Patten's idea, there should be as many commissures present as neuromeres. In Vermes the neuromeres of each segment contain but two cross commissures, although the segments are not double. The median furrow between the cross commissures in *Acilius*, if there is a furrow, which is doubtful, can hardly be similar to that between the successive neuromeres, for the latter are separated by a considerable distance. In such forms as *Julus*, Patten found the double nature of the somites indicated by the cardica ostia, arteries, tracheæ and legs, but this does not prove the double nature of the somites in insects. Embryologists in general, seem to have never found two pairs of tracheal invaginations in any one segment in insects. Patten's second pair of tracheal invaginations in *Acilius* has proved to be a mass of cells, easily mistaken for tracheal invaginations. Monsters with double appendages occur throughout the animal kingdom very frequently and are generally considered as abnormalities; not as a reversion to primitive types or conditions.

Lowne, '90, favors the compound segment theory of Patten, but thinks that it has not been sufficiently proved.

Banks, '93, in studying the chilopods observed a coalescence of the thoracic segments, less apparent in the lower forms (*Geophilus*) than in the higher ones (*Scutigera*) and from this concluded that the thorax of insects is composed of five segments, the first, third and fifth bearing legs, the second and fourth bearing wings. He points out in support of this theory that *Machilis* has a pair of small rudimentary appendages on each abdominal segment, which are also found on the meso- and metathorax in addition to the legs. From this, he argues, that the rudimentary appendages represent legs and hence, that the meso- and metathorax are compound segments.

These rudimentary appendages found in *Machilis* occur in other insects, also in Myriopoda and are the so-called styli—not vestigial legs. Jourdain, '88, considered these styli as homologous with the exopodite of Crustacea. Haase, '89, regarded them as modified setæ. Henneguy, '04, homologizes the styli with the epipodite of the crustacean leg and Verhoeff, '04, compares them to the coxal organs of Myriopoda. At present, however, it is not known exactly what the styli are, but they certainly are not regarded as vestigial legs by modern investigators. Banks' theory has no embryological support and furthermore, what occurs in chilopods is not necessarily any criterion of what occurs in insects.

Kolbe, '93, considers that the thorax is composed of three primary segments between which, he finds marked off, other "complementary segments," in such forms as the larvæ of *Lampyris* and *Raphidia*, also in *Locusta*, *Oedipoda*, etc. His conclusions are based principally on the larvæ of *Lampyris* and

Raphidia and he was the first to suggest the possibility of the occurrence of intersegmental or "complementary segments." This is not supported by embryology, however, which gives no indication of "complementary segments." Larvæ frequently acquire secondary adaptative structures, which cannot be considered as a retention of the primitive condition and the "complementary segments" of the above mentioned larvæ are probably some such secondarily acquired structures. Kolbe's theory needs more proof to support it than the presence of secondarily marked off regions in larvæ. A dissection of the larva of a beetle in which there are present "complementary segments" identical with those described by Kolbe in the larva of *Lampyris* demonstrates the following facts: that the "complementary segments" have no segmental muscles or other segmental structures; that the "complementary segment" is apparently a fold of the sternal integument and does not extend to the tergum; that it belongs to the segment in front of it and that each actual segment is marked off by an internal ridge, which extends completely around the body and has longitudinal segmental muscles connecting one ridge with the next. These three ridges probably define the three thoracic segments.

Walton, '00, is the exponent of another double subsegment theory which is similar to Banks'. He considers the coxa in the Hexapoda and Chilopoda as the fusion product of the appendages of two primary metameres which he terms, "coxa genuina" and "meron." The meron represents the rudimentary appendage of the posterior metamere, which articulates with the epimeron, and the "coxa genuina" represents the basal leg segment of the functional appendage of the anterior metamere, which articulates with the episternum and has persisted. From this he concludes that each segment is composed of two metameres. Walton's idea that the meron represents a vestigial leg is as improbable as Banks' view, that the styli of *Machilis* were the vestiges of legs. There is no embryological evidence to support Walton's theory and he has since repudiated it.

Comstock and Kochi, '02, think each thoracic segment is composed of two subsegments, which have become fused together. The line of division between them is represented in the tergum by the suture between the scutum and scutellum, in the pleuron by the pleural suture and in the sternum by the furcæ.

This theory is open to the same objections as the other compound segment theories previously stated, viz.: that embryology gives no indications of compound thoracic segments. Primitively the episternum and epimeron appear to consist of a single plate, a portion of which has become drawn inward, probably by muscular stress, forming a hollow infolding of the integument, which is represented externally by the pleural suture and internally by the lateral apodene. The anterior sclerite formed by this infolding of the pleuron, is termed the episternum, and the posterior sclerite, the epimeron. If this explanation be true, Comstock's and Kochi's view, as well as Banks' and Walton's idea which is very similar, namely, that the pleural suture is the line of union between two subsegments, must be regarded as untenable.

Verhoeff, '02-'04, made an extensive study of the comparative morphology of the insect thorax and his conclusions are based mainly on the thorax of the Chilopoda, Apterygota, Orthoptera, Dermaptera and Embiidæ. His theory is an elaboration of the views advanced by Kolbe. In studying *Japyx*, Verhoeff found in front of the "chief segments," represented by the pro-, meso-, and metathorax, indications of three other segments, which he called complementary segments and termed them micro-, steno-, and cryptothorax respectively. Thus the thorax would consist of six primary segments viz., micro-, pro-, steno-, meso-, crypto-, and metathorax. He found, on further study, that in front of each of these six primary segments were a few small sclerites, which he considered as the remains of six other segments and termed them the intercalary segments. Hence according to Verhoeff the thorax would consist of six primary and six intercalary segments, making a total of twelve thoracic segments, or in other words, each segment of the thorax consists of four annuli. This theory has been severely criticized by several writers and now is generally considered as incorrect. Silvestri, '02, and Börner, '03, criticized Verhoeff's views and the latter shows by his figures that Verhoeff's statements are erroneous. Börner states that the thorax is composed of three segments with intersegmental regions.

Voss, '04, gives Kolbe's and Verhoeff's composite segment theory, stating four possible modifications of it, which can be found in diplopods, *Scolopendra*, *Geophilus* and *Scolopendrella*. He thinks that the pre-segmental chitinous plates in insects are a secondary differentiation, explainable by mechanical causes as represented in lampyrid larvae.

Enderlein, '07, regarded the complementary segments in *Japyx*, which correspond to Verhoeff's micro-, steno-, and cryptothorax as "constricted-off" portions of the pro-, meso-, and metathorax and terms them the apotom of their respective segments. That is to say, they are detached portions of the pro-, meso-, and metathorax.

Desguin, '08, attacks Verhoeff's theory and shows that embryology, anatomy, musculature, etc., give no evidence in support of it. Other writers have criticized Verhoeff's ideas and it has been shown that all the facts seems to be contrary to his views. Unless further evidence is brought forth to substantiate Verhoeff's theory of the composition of the insect thorax it must be regarded as untenable.

Henneguy, '04, reverts to Kolbe's theory and expresses similar ideas. He finds in the larva of *Lampyris*, that each tergum covers two ventral "segments," the first of which bears a pair of spiracles and is known as the complementary segment, while the second segment bears a pair of legs. He finds these same conditions in *Scolopendrella* and from this concludes, first, that the Myriopoda are ancestors of insects; second, that the present position occupied by the spiracles in adult insects is explainable on the ground, that they are borne on the complementary segments. Henneguy finds traces of complementary segments in the thoracic region of elaterid and staphylinid larvae and in the abdominal region of carabid larvae. He finds that in the larva of *Raphidia*, the complementary segment between the pro-, and mesothorax, is a complete segment. The larvae of some Diptera appear to have double the number of segments present in other larvae of the same family, each complementary segment being produced by a transverse constriction of such a nature, that a sort of intermediate segment is formed between the normal segments. Henneguy states, that according to Brauer, this arrangement is due to a lengthening of the membrane uniting two consecutive segments, or to a secondary constriction of each annulus.

What has been said of Kolbe's theory will also apply to Henneguy's views. Henneguy's conclusions that Myriopoda are the ancestors of insects and that the position of the spiracle is to be explained by supposing that they were borne by the hypothetical complementary segment must have a firmer foundation before they can be accepted. Whether the spiracles belong to the segment in front of them or to the segment behind them is at present a disputed question. The spiracles are usually absent in the prothorax. It certainly seems more probable that the so-called complementary segments are parts of the pro-, meso-, and metathoracic segments, since this view is supported by embryology, anatomy, musculature, etc.

Woodworth, '06, states that "theories of composite segments in the thorax seem to be entirely untenable." He appears to consider the thoracic segment as originally made up of a solid ring, which later becomes split in the following manner. The development of the legs, results in the separation of the sternum from the remainder of the segment; in the beginning of the formation of the pleural suture; and of the suture which ultimately separates the scutum from the scutellum. The development of the wings results in the completion of the above mentioned sutures; in the development of the prescutum and postscutellum, and in the separation of the tergum from the pleuron. Hence he concludes that the wings are not the product of the pleuron or the notum, but are the means of their differentiation phylogenetically and ontogenetically.

Woodworth's conception of the thoracic segment is no longer accepted by most entomologists, although many originally held the same view. In all primitive insects and in larvae the sclerites arise as numerous islands of thickened chitin and not as a solid chitinous ring, which later becomes split up. In the more specialized insects these small sclerites become more or less fused together. This can be clearly demonstrated by studying a series of insects beginning with larval and primitive forms as *Eosentomon*, and gradually working up to the more specialized groups.

Berlese, '06, regarded each thoracic segment as originally made up of a "tergite" and "sternite." The "tergite" was one solid piece which included the "alar sclerites," the spiracles, the tergum and the epimeron. The "sternite" is composed of four pieces which he termed the acro-, pro-, meso-, and metasternites. The acro and prosternites constitute the "sternum," while the meso- and metasternites form the "sternellum." With this as a basis Berlese accounts for the sclerites which make up a typical thoracic segment in the following manner. First, the epimeron became split off from the "tergite," while the leg appendage arose from a part of the "metasternite" and later the trochantin, consisting of two pieces became split off from the "sternellum," in the region of the coxa. Next, the epimeron entered into the composition of the pleuron near the coxa and the two "alar plates" at the base of the wings, together with the spiracles, became detached from the "tergite." The "sternum" became split up into pieces to form the episternum and sternum. It is obvious that Berlese's theory is untenable. Considered from an embryological and anatomical point of view, it has no foundation whatever.

The later writers, Crampton, '08-'09 and Snodgrass, '09-'10, think that the thorax of insects is composed of three segments. This view is supported by embryology and anatomy and is based upon facts, while all the composite segment theories are more or less lacking in such support, are not always based upon facts and consequently are untenable.

Dr. Prell, '13, who has recently published a paper on the Myrientomata, views the insect thorax as follows: In the abdomen of *Acerentomon*, he finds that each segment is divided into four rings, which are further subdivided into regions by sutures. In the thorax of *Eosentomon* these rings are represented by a number of sclerites which have become more or less displaced from the ring arrangement, owing to the specialization of the thorax for locomotion. The sternal region is composed of four subdivisions, which he terms the acro-, pro-, meso-, and metasternite. The tergal region is also composed of four subdivisions, the acro-, pro-, meso-, and metatergite and in addition a region called the nototergite becomes secondarily marked off from the metatergite. In the pleural region of each segment, he finds two longitudinal rows of sclerites. Those bordering on and extending along the lateral margin of each thoracic sternum, he terms the sternopleura or pleura in the restricted sense. Those which border on and extend along the lateral margin of each tergal region, he terms the sympleura or tergal pleura. Both sympleura and pleura are composed of four sclerites, lying one behind the other. The dorsally situated sympleura are termed, acro-, pro-, meso-, and meta-sympleurites, while the sclerites composing the more ventrically situated row are termed the acro-, pro-, meso-, and meta-pleurites. The pleura and sympleura, he thinks, are detached portions of the region, which he terms the zygoterga. The zygoterga is the region comparable to the dorsal or tergal half of the abdominal segment. Thus he considers that each thoracic segment is composed of four subsegments designated by the terms acro-, pro-, meso-, and meta-subsegments, that the dorsum is composed of four tergites and the sternum of four sternites, designated by the above mentioned prefixes. He regards the lateral region as consisting of two longitudinal rows of sclerites (i. e., the upper row or sympleura and the lower row or pleura) and considers that they are detached portions of the zygoterga.

DISCUSSION OF THE THORACIC SCLERITES.

TERGUM. The term dorsum has been used to designate various parts of the dorsal surface of the thorax in different insects, but when correctly applied it refers to the entire dorsal surface and this usage will be followed here. The terms tergum and notum will be used interchangeably to designate the entire dorsal surface of any one thoracic segment. These terms are generally used in this sense and if given any other meaning, would lead to confusion.

In the nymphs of the lower insects as well as in many larvæ and pupæ, the tergum is a single undivided plate, the scuto-scutellum (Crampton, '09). This is probably the primitive condition of the tergum, which has possibly persisted in a more or less modified condition in the pronotum of adult insects. The fact that no postscutellum has ever been described as occurring in the pronotum of insects, supports this view. The postscutellum in adult insects, develops in the intersegmental membrane of the mesonotum and metanotum, its development being apparently parallel with the development of the wings, which is possibly due to anatomical causes such as the stimulus of muscle stress, etc. Snodgrass, '10, calls the postscutellum the "postnotum" or "pseudonotum." There is no reason for rejecting Audouin's term postscutellum, which is suitable, widely used and generally accepted. Hence it will be retained in this paper.

Verhoeff, '02–'04, Voss, '04, and Snodgrass, '09, have proven conclusively that the tergum is composed of but two plates, the scutoscutellum (Crampton, '09) and the postscutellum (Audouin, '24), the latter being absent in the pronotum, (Fig. 13, scsl, psl). The anterior plate or scutoscutellum is generally marked off by transverse sutures into three regions, the prescutum, scutum and scutellum, but sometimes the sutures which mark the boundaries of these regions are absent(Fig. 13, prsc, sc, sl). In many insects the posterior plate or postscutellum is divided longitudinally into a median and two lateral regions, which may be subdivided (Fig. 1, psl). Crampton, '09, termed these regions the mediophragmite or median region and pleurophragmites or lateral regions. I shall use the terms mediotergite and pleurotergite for these regions, because they are subdivisions of the tergum (Fig. 1, mt, plt). When they are further subdivided by a transverse suture, Crampton, '09, refers to the subdivisions as the superior and inferior region of their respective medio- or pleurophragmite (medio- or pleurotergite). I shall refer to the subdivisions of the medio- and pleurotergite in the same manner (Fig. 1, spplt, iplt). In *Tipula* the pleurotergite is divided transversely into the superior pleurotergite and inferior pleurotergite (Fig. 1, spplt, iplt). In other Diptera such as *Leptis*, *Tabanus*, etc., the pleurotergite is subdivided by a longitudinal suture into the outer and inner pleurotergite (Figs. 2 and 11, oplt, inplt). Crampton, '09, previously used these adjectives to designate the outer and inner "pleurophragmite."

The scutellum projects laterally on both sides, until it meets the posterior margin of the wing. (Fig. 1, sl). The prescutum and postscutellum are often continued laterally on either side until they join the pleuron, although frequently these lateral prolongations become much reduced in size or split up into smaller pieces (Fig. 2, prsc, psl). Projecting internally, sometimes from the anterior margin of the tergum, sometimes from the posterior margin, or from both, is a process termed the phragma, which serves for the attachment of muscles. When the phragma is attached to the anterior margin of the tergum, it is termed the prephragma and when attached to the posterior margin, is termed the postphragma (Snodgrass, '10). The prescutum and postscutellum are frequently represented in the tergum of insects simply by the inward projecting phragmas. In some insects the postscutellum is completely separated from the scutoscutellum by membrane. (Fig. 10, psl).

The old view that the tergum of adult insects consists of four consecutive transverse plates was proposed by Audouin, '24. He termed these plates the presecutum, scutum, scutellum and postscutellum, and this terminology has been retained though Audouin's general conception of the tergum, held until recently by most entomologists, is now obsolete. Other writers have given various names to the different tergal regions. Amans, '85, proposed the terms prodorsum, dorsum, postdorsum and subpostdorsum for the identical sclerites previously termed prescutum, scutum, scutellum and postscutellum by Audouin. Audouin's terminology has the right of priority, is widely accepted, has no undesirable features and should therefore stand.

WINGS. The wings of insects arise in two ways. In hemimetabolous insects they appear as outgrowths at the lateral margins of the meso- and metanotum. In holometabolous forms, they arise internally as the so-called wing-buds, appearing externally at or after pupation. At first the wings are filled with tracheæ, blood, tissue, etc. The tracheæ persist and are ultimately replaced by the veins or nervures of the adult insect wing, which serve as stiffening supports for the wing membrane. The blood and tissue gradually disappear and the two lateral surfaces of the sac-like outgrowth come together, forming the wing membrane.

The wings of adult insects are connected with the scutoscutellum along its lateral margin, on the lateral margin of the tergum. They articulate with the pre- and post-alar processes, together with the small alar sclerites at the base of the wing (Fig. 10, pra, poa, sa, ba). Beneath they articulate with the pleural wing process (Fig. 10, plwp).

The wings are variously modified in different insects, forming the elytra of Coleoptera, the tegmina of Orthoptera, the halteres of Diptera, the hemielytra of Hemiptera and the hairy and scaly wings of Lepidoptera and Trichoptera. In such forms as Carabidæ, Ptinidæ, and weevils the hind wings are often lacking, owing to disuse, and the elytra in some forms fuse together thereby forming a solid covering for the hind wings (if present) and the abdomen. The general belief has always been that elytra are modified wings.

In homologizing the wings in the different orders of insects, by their venation, Comstock made use of the tracheæ, which occupy the position afterwards assumed by the principal veins in the wings of generalized insects. He termed the veins costa, subcosta, radius, media, cubitus, and anals. This terminology is quite widely accepted and generally used, especially for Lepidoptera.

Several theories have been proposed to account for the origin of the wings. Gegenbauer, '70, claimed that the wings developed from tracheal gills. Palmen, '77, discredited this theory by demonstrating that tracheal gills occur on the sternum, abdomen, tergum, pleuron and in the anal region; that tracheal gills and the closed tracheal system is a secondary adaptation to the aquatic life of the larva and that aerial respiration was probably the primitive condition.

Plateau, '71, thought that the wings developed from hypertrophied spiracles. Müller, '75, from a study of the development of the wings of *Calotermes*, concluded that they arose as lateral outgrowths of the dorsum. To this theory Pancritius, '84, adds the idea, that the primitive outgrowth of the body wall may have developed into a protective body covering like an elytron, which became modified to form the wings. Packard, '98, accepted and developed Müller's theory. He apparently thought that primitive winged insects had lateral extensions of the thoracic segments, which acted as a sort of parachute and which later gave rise to true wings. Palaeontological records show that some insects had lateral extensions of the pronotum which may have served as a parachute and that many of the earliest of the Pterygota have well developed wings, which seem to have articulated with the thorax. Packard's theory is plausible.

PLEURON. The pleuron in a restricted sense consists of the sclerites lying between the dorsum and sternum and forming the lateral wall of any thoracic segment. In nearly all insects it is composed of two sclerites, the episternum or anterior sclerite and the epimeron or posterior sclerite (Fig. 8, es_1, em_1). In the higher forms, the pleuron is usually connected with the tergum by prolongations of the prescutum and postscutellum, the latter often extending downward for some distance and fusing with the pleuron, in which case it is frequently mistaken for a part of the pleuron (Figs. 2 and 11, psl, prsc). These prolongations of the tergum are usually lacking in the lower forms. In other insects they may be much reduced in size or split up into smaller pieces.

The episternum and epimeron are separated externally by a suture, termed the pleural suture, which extends from the pleural wing process or fulcrum to the pleural coxal process (Fig. 1, pls_2). Internally these two sclerites may be readily distinguished from each other by a strongly chitinized ridge variously termed the pleural ridge, entopleuron or apodeme, which likewise extends from the pleural wing process to the pleural coxal process.

The pleuron bears three processes which usually have an inward projection for the attachment of muscles. Above is the pleural wing process which serves for the articulation of the wing (Fig. 2, plwp). It consists of a dorsal prolongation of the pleuron, of variable length, through which runs the pleural suture externally and the entopleuron internally. On the lower margin of the pleuron is the pleural coxal process, with which the coxa articulates (Fig. 4, cxp). It is similar to the pleural wing process and has the pleural suture and pleural ridge extending through it. The pleural process or pleural arm (Snodgrass, '10) is situated a short distance above the coxal process. It projects inward and downward from the entopleuron. Usually it rests against the furca (an inward projecting process of the sternum, termed the apophysis) and frequently fuses with it (Fig. 12, f).

Along the dorsal edge of the pleuron are generally found three or four small sclerites. Two of these, the basalar plates (Crampton, '14) are generally found in front of the pleural wing process, and are termed by Crampton, '14, the anterior and posterior basalar sclerites, terms which will be used in this paper (Fig. 2, pba, aba). Behind the wing fulcrum there is usually one, sometimes two of these sclerites, which are termed subalar plates (Crampton, '14, Fig. 2, sa). Lowne, '90, in his book on the Blow-Fly, terms the subalar plate, the "costa." Snodgrass, '08, terms it the "postepimeron" and Crampton, '09, the posterior "costal sclerite." Verhoeff termed the anterior basalar plate, the "alarpleura." Snodgrass, '10, termed all these plates the "paraptera." Those situated in front of the wing process, he called the preparaterum or episternal paraptera and those behind the postparapterum or epimeral paraptera. Snodgrass claims in his "Anatomy of the Honey Bee," pp. 20, footnote (a), that Audouin, '24, termed these plates the paraptera and hence Snodgrass would retain this term. This, however, is not the case. Audouin, '24, termed the small sclerite which sometimes extends along the anterior edge of the episternum the "paraptere" and confuses it with the tegulae and other sclerites at the base of the wing. Later Audouin, '32, clearly defined the "paraptere" as the tegulae (1832 Audouin, Exposition de L'anatomie du Thorax. par W. S. MacLeay, Accompagnee de notes par M. Audouin. Ann. Sci. Nat. XXV, Ser. 1, pp. 41, footnote.) He says: "In fact I consider as the paraptere the small piece so visible in the Hymenoptera and in the Lepidoptera, which covers the base of the fore wings and which has been designated by the name ecaille, epaulette or squamala." Jordan, '02, terms the subalar plate the "parasternum" and also applies this term to the anepisternum (upper portion of the episternum) in his figures. His homologies of the sclerites are evidently incorrect. Berlese, '06, termed the basalar sclerites the "acrosterno o prefulcro (anteriore e posteriore)." The subalar sclerite he terms the "paraptero," (Gli Insetti, pp. 244). "Prefulcro" is a good term for the basalar sclerites, as it designates their position in front of the wing fulcrum, but the term "paraptero" does not seem desirable. Crampton's, '14, term, subalar sclerites, is far more suitable since it exactly describes the position of these sclerites.

The pleuron may be more or less modified in different insects. In the mesothorax of some Diptera, the parts have shifted forward, thereby causing the pleural suture to become twisted and curved (Fig. 11, pls_2). In Odonata the pleuron assumes an oblique position and as a result, the episternum becomes dorsal and the epimeron ventral. In other insects the pleural sclerites are variously modified in shape and size.

Crampton, '08, was the first to suggest that the pleuron probably consisted originally of but one plate and that the episternum and epimeron may have been formed by the infolding of the integument, due to muscle stress. This view was later developed by Snodgrass, '09. In such insects as *Eosentomon*, *Leuctra* (prothorax), acridid nymphs and *Anisolabis*, the pleuron is apparently represented by a single plate, in which the pleural suture is present. If the pleuron was originally a single plate, which seems very probable, then the pleural suture probably arose by an infolding of the integument of this plate. In the pleuron of *Periplaneta* for example, the line which represents the pleural suture is clearly formed by the two external lips of the infolded integument coming together and resting against each other, but the edges or lips do not fuse. On pressing the edges or lips of the fold apart, a large hollow pocket will be seen, at the bottom of which is the apodeme and the pleural arm. The pleural arm is sometimes hollow and usually chitinized. These conditions would be produced by the infolding of the integument of the pleuron, possibly due to muscular stress, possibly from other causes. This is the simplest and most probable explanation.

Some investigators regard the pleuron as being formed by two sclerites coming together, fusing and the edges rolling inward to form the pleural suture and apodeme. This view seems very improbable. It is complicated and does not account for the single plate representing the pleuron in *Eosentomon*, *Leuctra*, etc. Furthermore, two sclerites whose edges meet and fuse are not apt to be plastic enough to permit their being drawn out into a prolongation forming the pleural arm and pocket, but would more probably be firm and resistant.

Audouin, '24, considered the pleuron as composed of three sclerites, the anterior or episternum, the posterior or epimeron and the peritreme or spiracle bearing sclerite. This terminology is widely accepted (with the exception of peritreme) in general use and there is no valid reason for changing it as some writers have done, since this only leads to confusion. Kirby refers to the epimeron as the pleura. Burmeister thought the pleuron was part of the sternum and others regard it as the basal sclerites of the leg.

Heymons, '99, in his "Beitrage zur Morphologie und Entwichlungsgeschichte der Rhynchoten," pp. 443, in discussing the sclerites of *Nepa*, was the first to use the term subcoxa and applied it to what he thought was the mesothoracic pleuron, consisting of episternum and epimeron. A study of *Nepa* shows that Heymons' subcoxa actually consists of the mesothoracic episternum, the precoxal bridge or precoxale (Crampton, '14), and possibly the trochantin. The sclerite in *Nepa* which Heymons thinks is the metathoracic pleuron, he terms the "pleurite," pp. 376. This sclerite is not the metathoracic pleuron, but is the epimeron of the mesothorax. It extends posteriorly as a sort of flap covering the metathoracic epimeron, which would easily escape notice unless closely observed. Heymons was confused in the use of his own term subcoxa, which has led to its misinterpretation by other workers. Enderlein and also Berlese thought the "subcoxa" corresponded to the trochantin. Börner considered it equivalent to his "merosternum" or pleuron. Verhœff regarded it as representing the coxopleure (episternum) and trochantin.

EPIMERON. The epimeron varies greatly in size and shape in different insects. Most writers consider it as a single sclerite, which is usually the case (Fig. 8, em_1).

In the prothorax of *Periplaneta* there is a small sclerite, which has become split off from the posterior edge of the epimeron, and may be termed the postepimeron (Fig. 3, pem_1). Snodgrass, '08, applied this term to the subalar plate. It has since been discarded and so far as I know, has never been applied to any other sclerite. Therefore, as it describes the exact position of the sclerite, which has become detached from the posterior edge of the epimeron, I have adopted it to designate the sclerite in question. In the prothorax of *Capnia* (Fig. 4, pem_1), there is a large sclerite comparable to the postepimeron, which is likewise split off from the posterior edge of the epimeron and extends behind the coxa until it meets the furcasternite, thereby forming the postcoxal bridge or postcoxale (Crampton, '14). In the mesothorax of *Corydalis* (Fig. 10, pem_2) the epimeron is a single sclerite, a projection of which extends behind the coxa. In many Coleoptera and Tenthredinidæ (prothorax of *Dolerus* (Fig. 12, em_1) the epimeron is greatly reduced in size.

The epimeron is often divided into two sclerites by a transverse suture. This condition can be seen in the mesothorax of such insects as *Mantispa*, *Chrysopa*, *Leptis*, and in some Tipulidæ and Tabanidæ (Figs. 1 and 2, em_2). In Diptera the lower portion of the epimeron of the mesothorax is usually fused with the meron, being separated by a suture, although the suture is often wanting (Figs. 1 and 11, mp). Packard, '80, seems to have been the first to apply terms to the subdivisions of the epimeron. In describing the thorax of Mantispa, he termed the upper region, the sur-epimeron and the lower the infra-epimeron. Crampton, '08, used the terms hyper- and hypo-epimeron for these regions, but on account of the similarity of the terms he later (Crampton, '09), discarded them, substituting in their place anepimeron and katepimeron.

Osten-Sacken's terminology has been widely used for the Dipteron thorax and is very good. Crampton, '14, retains it in a slightly modified form, viz.: changing the ending from pleura to pleurite. Thus in the Diptera, Crampton, '14, terms the upper region of the epimeron the pteropleurite (situated beneath the wing base (Fig. 1, ptp) and the lower region meropleurite (usually fused with the meron, especially in Diptera (Figs. 1 and 11, mp). These terms will be adopted in this paper.

Some Diptera such as *Tipula*, *Chrysopa*, etc., have the lower portion of the epimeron separated from the meron by a suture. In such cases the term katepimeron (Crampton, '09) will be applied to the lower portion of the epimeron (Figs. 1, 2 and 13, kem). The term meropleurite will be applied to the katepimeron plus the meron whether these sclerites are completely fused into one as in the mesothorax of *Tabanus* (Fig. 11, mp), or separated by a suture as in *Tipula* and *Chrysopa* (Figs. 1 and 13, mp). In either case the meropleurite represents identical regions (Figs. 11 and 13, mp).

The subalar plate or its representative is always present behind the pleural wing process (Figs. 1, 2 and 11, sa). It may be partly fused with the epimeron or entirely separated from it by membrane. Both of these conditions can be found in the Diptera (*Leptis*, *Tabanus*, etc., Figs. 1 and 2, sa). Sometimes the subalar plate is divided into two sclerites as in some of the Plecoptera, and in that case will be termed anterior and posterior subalar sclerites (Crampton, '14). In some Leptidæ and Tabanidæ, there is a cleft immediately below the subalar plate (Figs. 2 and 11, sa), which is prolonged downward into the epimeron (pteropleurite, ptp) for a short distance in the form of a suture, but the internal ridge of this suture is not continuous with the pleural suture. Snodgrass, '10, mistook this suture for the pleural suture, which it closely resembles when viewed externally. By carefully examining a specimen which has been boiled in caustic potash, the mistake will be readily discovered and the real pleural suture can be easily traced by means of the apodeme, from the coxal process into the pleural wing process (Figs. 2 and 11, pls_2).

In studying the thorax in a series of insects such as *Mantispa*, *Chrysopa*, *Tipula*, *Leptis* and *Tabanus*, it will be observed that there is a gradual shifting forward of the sclerites, being most pronounced in the mesothorax (Figs. 13, 1, 2 and 11). This causes the pleural suture of the mesothorax to become more or less crooked as shown in Figs. 1, 2 and 11, pls_2.

Starting at the upper end of the mesothoracic wing fulcrum of Tabanus (Fig. 11, plwp) the pleural suture (pls_2) runs downward and slightly forward in a more or less curved line until it meets the sternopleurite (lower region of the episternum). (Fig. 11, stp). Here it turns almost at right angles and runs posteriorly to the meropleurite (lower portion of epimeron), (Fig. 11, mp) and thence downward and slightly backward to the coxa. This condition is very confusing and hard to see, unless the specimen is first boiled in caustic potash, in which case the pleural suture is readily observable.

In Diptera the meron is often fused with the lower region of the epimeron, forming the meropleurite (Fig. 11, mp), but as the former sclerite is usually closely connected with the coxa it will be treated under the heading Coxa.

Audouin, '24, applied the term epimeron to the sclerite immediately posterior to the episternum. This term has been generally accepted and used by nearly all subsequent entomologists. The epimeron was termed by Burmeister, '32, the "pleura;" by Verhoeff, '03, the "anopleure;" by Amans, '85, the "postpleuron," and by Heymons, '99, the "pleurite." Hammond, Brauer and Lowne who have worked on the Dipteron thorax, where the epimeron is often subdivided into two sclerites, have applied the term epimeron to various thoracic sclerites and the terminology has been greatly confused. Osten-Sacken's terminology for the thorax of Diptera is very good and should be retained. Crampton, '14, in a review of the Dipteron thorax has retained this terminology slightly modified as previously stated. This terminology should also be applied to all insects in which the epimeron and episternum are subdivided as in *Mantispa*, *Chrysopa*, *etc.*, since it has been established by wide-spread acceptance among those working on Diptera and should be made a uniform terminology for all insects with a thorax of this nature, as far as possible.

The term parapleuron has given rise to much confusion among morphologists. It was first applied to the entire pleural region by Knoch. Kirby termed the epimeron and episternum, the parapleuron, an interpretation accepted by Smith, '06. Burmeister and also Voss applied the term parapleuron to the episternum. Kolbe used it for a sclerite occurring in beetles, situated behind the wing and between the tergum and pleuron. Ritter's parapleuron is equivalent to the anepisternum or upper region of the episternum. Others have used the term parapleuron to designate various sclerites of the thorax. At present there is no uniformity of opinion concerning the application of the term even among Coleopterologists, by whom it is chiefly used.

EPISTERNUM. The episternum is also subject to great variation in insects. It may consist of a single sclerite as in the earwig (Fig. 8, es_1), or it may be subdivided into an upper and lower region as in *Mantispa*, *Chrysopa*, *Corydalis*, *Tipula*, etc. (Fig. 2, es_2). The suture which divides the episternum into two regions may extend clear across, making a complete division, as in the mesothorax of *Tabanus* (Fig. 11, g) or only part way, as in the mesothorax of *Tipula* (Fig. 1, g). In *Chrysopa* and *Mantispa* (Fig. 13), the division is represented by a narrow strip of chitin of varying width, extending inward midway between the two subdivisions. This strip is probably a part of the episternum which has become fused with the precoxal bridge (Crampton, '14). It may, however, belong entirely to the precoxal bridge, a projection of which extends between the two subregions, but this latter alternative is very improbable. The formation of this region in other insects seems to indicate that it is a part of the episternum. Crampton, '09, applied the term "median region," to this narrow strip of chitin. This seems to be the only term which has been applied to it. It hardly seems necessary to give this region a name and consequently none will be used in this paper.

When the episternum is subdivided, a condition found in a great many insects, the lower division may be fused with the sternum (Figs. 1, 2 and 11, stp). The episternum is separated from the epimeron by the pleural suture. In all insects, both the episternum and epimeron extend from the coxal process to the pleural wing process. This condition can be plainly seen in most insects, but in some such as Tabanus, etc. (Fig. 11, stp), the lower portion of the episternum of the mesothorax has become fused with the sternum. Many workers have considered this fusion product of sternum and lower portion of the episternum as the entire sternum and accordingly termed it the sternum. This misinterpretation has led to great confusion in the terminology. In the mesothorax, Lowne termed this composite region the "mesoplastron." He also applied the term, "metaplastron" to the meropleurite (lower portion of epimeron fused with the meron) of the mesothorax (Fig. 11, mp). Chabrier had originally used the term "plastron" to designate the pleuron of the prothorax, so that Lowne is incorrect in stating that the "mesoplastron" is the "plastron" of Chabrier. Packard, '80, used the terms sub- and infra-episternum to designate the fusion product of the sternum and lower region of the episternum. Snodgrass, '10, and several other workers termed it the "sternum." Osten-Sacken, '89, used the term "sternopleura." Crampton, '09, designated it by the component parts entering into its composition, but later Crampton, '14, adopted Osten-Sacken's terminology, slightly modified, calling it the sternopleurite. The latter term will be used in this paper.

The lower portion of the episternum in *Chrysopa* and like insects has a new region marked off, which is composed of a different combination of sclerites than the region representing the sternopleurite in *Tabanus*, and hence has been termed pleurotrochantin, (Crampton, '14) (Fig. 13, pltn). This term will be retained in this paper. The pleurotrochantin is composed of the lower part of the episternum, most of the trochantin and the antecoxale. The term sternopleurite, however, will still be applied in *Chrysopa* and like insects, to the pleurotrochantin plus the precoxale and sternum (Fig. 13, stp), since this region would then be identical with the sternopleurite of Diptera (Fig. 11, stp). In this way a uniformity of terminology is retained.

The upper region of the episternum is a more or less square sclerite, which has become pushed forward in the mesothorax of such insects as Tabanus (Fig. 11, esp), due to the shifting forward of the parts as previously mentioned. The upper margin of this sclerite and also the pteropleurite (upper portion of the epimeron) often contain clefts of varying depth and width (Figs. 2 and 11). The shifting forward of sclerites naturally led to their misinterpretation by different workers and finally resulted in a confused terminology. Packard, '80, termed the upper region of the episternum, the "sur- and supra-episternum.' Hammond, '81, called it the "parapteron." Brauer, '82, and several other workers called it the episternum, while Snodgrass, '09, included a portion of the pteropleurite (upper region of the epimeron) and the upper region of the episternum together, as the episternum. Lowne, '90, termed it the lateral plate of the "mesosternum," Petri, '99, the "antepleura," borrowing Amans '85, term for the entire episternum, (antepleuron). Osten-Sacken, '84, termed it the "mesopleura," which is inappropriate, because it is not the entire mesopleuron. Crampton, '08, called it the "hyper-episternum" and later, Crampton, '09, the "anepisternum." I shall adopt for it the term anepisternum. In *Chrysopa*, *Mantispa*, etc., (Fig. 13, esp, ptp) the terms anepisternum and also pteropleurite have been used for the upper portions of the episternum and epimeron, since these regions are homologous with those found in Diptera (Fig. 11, esp, ptp).

In the meso- and metathorax of *Periplaneta* the episternum consists of one sclerite, which is fused with the precoxal bridge or precoxale (Crampton, '14) (Fig. 3, es, es_3). The trochantin is partially attached to the episternum in the prothorax (Fig. 3, tn_1). The episternum, together with the epimeron form a deep hollow pocket by the infolding of the integument, which bears internally the pleural process. The episternum in the earwig consists of a single sclerite (Fig. 8, es_1).

In *Capnia* the prothoracic episternum consists of one piece (Fig. 4, es_1). The meso- and metathoracic episternum is divided by a suture into an upper and lower portion (Fig. 4, esp, pltn) giving a condition comparable to that found in Chrysopa (Fig. 13, esp, pltn). Here also we have the beginning of a condition similar to that found in *Tabanus* (Fig. 11, esp, stp). The fusion of the sternum with the lower portion of the episternum, precoxale, etc., suggests the probable formation of the sternopleurite (Figs. 1, 2 and 11, stp).

In *Corydalis* the condition of the episternum in the mesothorax is similar to that found in *Capnia* and *Tabanus*. (Fig. 10, esp, stp). The suture dividing the episternum becomes more pronounced and takes the form of a deep cleft. The precoxale, sternum and episternum become more closely fused.

Packard, '80, in his figures of *Corydalis* shows the episternum extending from the coxa to the wing process. He also includes the trochantin and precoxal bridge as part of the episternum. Crampton, '09, considered the episternum as extending from the coxal process to the pleural wing process. Snodgrass, '09, regarded the anepisternum (upper portion of episternum) in *Corydalis*, as the entire episternum (Fig. 10, esp). The episternum, however, extends from the coxal process to the pleural wing process, as is very clearly illustrated in *Periplaneta*. Most writers fail to take this fact into consideration and consequently the resulting misinterpretation and confusion.

In *Dictyophora* and *Dissosteira* the sternum, episternum and precoxale are closely united. This condition is more or less pronounced in the various insect orders. In the pro-, meso- and metathorax of *Forficula* (Fig. 8, pc_1, pc_2, pc_3) and in the mesothorax of *Gryllus*, (Fig. 7, pc_2) the precoxale becomes split up and is not fused with the sternum. In the prothorax of *Gryllus*, however, the episternum, precoxale and sternum are closely united (Fig. 7, pc_1, es_1, vs_1).

Audouin, '24, termed the anterior plate of the pleuron the episternum. This term is still in use and accepted by everyone. When the episternum is subdivided it is necessary to use other terms to designate the subdivisions, as previously discussed in the case of *Tabanus*, *Mantispa*, *Chrysopa*, etc. Burmeister, '32, termed the episternum the "parapleura." Packard, '80, called the upper portion the sur- and supra-episternum and the lower portion the sub- and infra-episternum, using the former and also the latter terms interchangeably. Packard studied a large number of insects and used the terms, "pleurites" and "sternites," in his terminology. Although his homologies of the sclerites are incorrect in many cases, his ternimology has many good points. His work on the whole is very good and has not been accorded sufficient attention. Amans, '85, termed the episternum the "antepleuron." Jordan, '02, applied the terms "para-sternum" and "episternum" to the anepisternum (upper portion of episternum). The term "parasternum" he also applies to the basalar plate. The sternopleurite (lower portion of episternum fused with a part of the sternum), he terms "hyposternum." He confuses his own terms by misinterpreting the sclerites in different papilionids. In *Forficula*, Verhoeff, '03, termed the episternum the "coxopleure," while in the roach his "coxopleure" consists of the precoxale together with the episternum.

Audouin's, '24, term episternum is satisfactory and generally accepted, while the other terms applied to the episternum are useless synonyms. This confusion was brought about by the misinterpretation of sclerites and by the tendency of writers to set forth their own ideas of the terminology. In doing this, they have invented new terms to suit their respective views and have not given sufficient attention to the work and terminology of previous investigators.

PRECOXALE. The precoxale is situated in front of the coxa and is either united or completely fused with the episternum. The end of this sclerite nearest the sternum may be free as in *Periplaneta* (Fig. 3, pc_1), or it may be united or fused with the sternum as in the mesothorax of *Capnia* (Fig. 4, pc_2), thereby forming a bridge connecting the episternum with the sternum. Hence the term precoxal bridge or precoxale of Crampton, '14. The portion nearest the sternum is sometimes split transversely into one or two small sclerites, as in the mesothorax of *Forficula* (Fig. 8, pc_2). In other cases the precoxale is entirely fused with the episternum and sternum as in the Coleoptera, Formicina, Diptera, etc. (Fig. 10, pc). A portion of it may fuse with the episternum and a portion with the sternum as illustrated in the metathorax of *Forficula* (Fig. 8, pc_3), or it may disappear as in the prothorax of *Macroxyela* (Fig. 14). The division between sternum and episternum in the metathorax of *Forficula* (Fig. 8, es_3, vs_3) is probably secondary, although this condition is open to other interpretations.

The precoxale, while constant in position is extremely variable in size and form. In *Periplaneta*, which is admittedly a very primitive insect, the precoxale is similar in all three thoracic segments, its dorsal portion being always fused with the episternum, except in the prothorax, while the ventral portion borders on the sternum, but is not strongly connected with it (Fig. 3, pc_1, pc_2, pc_3). In the meso and metathorax, there is a deep cleft in front of the pleural wing process, at the mouth of which is a small sclerite, comparable to one of the basalar sclerites, previously discussed (Fig. 3, pba_2, pba_3).

The other basalar plate is probably represented by a small sclerite, which is marked off on the upper corner of the precoxale by a heavy suture (Fig. 3, aba_2, aba_3).

In *Periplaneta* there is a suture which divides the meso- and metathoracic episternum and precoxale (Fig. 3, 0). Part of it can be plainly seen and the other part (represented by the dotted line) is rather faint and hard to see. If the specimen is first boiled in caustic potash, the suture can be more easily distinguished. This suture suggests very strongly the beginning of the formation of a sclerite, comparable to the anepisternum (upper portion of the episternum) of the Diptera. In some roaches it is represented by one heavy suture, plainly seen throughout its entire length.

Along the anterior margin of the metathoracic precoxale there is marked off a small sclerite, which I shall term the pre-episternum (Fig. 3, pes_3). It seems to be homologous with Audouin's '24, "hypoteron." Hopkins first used the term pre-episternum to designate the sclerite which Audouin termed the "hypoteron," in *Dytiscus* and it should be applied to that sclerite only. Jordan, '02, terms the pre-episternum the "peristernum." Snodgrass, '09, has used the term pre-episternum, but is so inconsistent in its application that it is hard to tell what his pre-episterum represents. In his various figures, he has designated the episternum, precoxale, one of the basalar sclerites and the pre-episternum proper, by the term pre-episternum. In his "Thorax of the Hymenoptera," he calls the pre-episternum the "prepectus."

Immediately posterior to the precoxale in *Periplaneta*, a narrow sclerite is marked off, the antecoxale of Crampton, '14, whose term I shall adopt for this sclerite. This sclerite is folded under the precoxale in the prothorax (Fig. 3, ac_1) and is homologous with the lateral portion of the antecoxal piece of Coleoptera. It is connected with the precoxale in *Periplaneta* by very thin or non-pigmented chitin, not by membrane. This suggests that it is probably derived from the precoxale by a secondary longitudinal marking off. In other insects it has either disappeared or become fused with other sclerites which surround it, such as the trochantin, precoxale, etc. The antecoxale was termed by Walton, '00, the "antecoxale piece;" by Comstock, '02, the "second antecoxale piece," and by Crampton, '09, the "antecoxale laterale." Verhoeff, '03, terms it the "katopleura" in the roach, but in the Forficulidæ he applies the term "katopleura" to an entirely different sclerite.

In *Forficula* the condition is quite different from that found in *Periplaneta*. In the prothorax the precoxale may have fused with the trochantin and episternum following which there was a secondary marking off, of a triangular sclerite, consisting partly of trochantin and precoxale (Fig. 8, tn_1), and of two narrow sclerites extending along the anterior margin of the episternum (Fig. 8, pc_1), which represent a part of the precoxale, the rest of it having fused with the episternum. Another view is that the triangular sclerite (Fig. 8, tn_1) represents the entire trochantin and that the two narrow sclerites along the anterior edge of the episternum represent the entire precoxale (Fig. 8, pc_1), which has become reduced in size. The precoxale in *Diapheromera* is very narrow and reduced in size, thus showing that such a condition is not at all abnormal or improbable.

In the mesothorax the precoxale has become split transversely into two sclerites (Fig. 8, pc_2). For the sclerite nearest the sternum, I suggest the term sternocoxale (Fig. 8, stc) and for the sclerite nearest the pleuron, the term pleurocoxale (Fig. 8, plc). In the metathorax a portion of the precoxale may have fused with the episternum, sternum and trochantin (Fig. 8, pc_3). How much has fused with each, it is impossible to say. Another view is that the pleurocoxale has fused with the episternum; the sternocoxale with the sternum and the triangular sclerite (Fig. 8, tn_3) represents the entire trochantin. In the thorax of Forficula there is no complete connection between the episternum and sternum.

There is a small sclerite between the pleural region and sternum in the mesothorax of *Gryllus*, which is homologous with the sternocoxale (Fig. 7, stc). Voss termed it the "coxosternite."

In Locusta, *Capnia*, *Corydalis*, and many Lepidoptera, Diptera, Coleoptera, etc., the precoxale is usually fused with the episternum and sternum, forming a continuous bridge between them (Fig. 4, pc_2). Secondarily formed sutures often appear in this bridge or precoxale, as in *Capnia*, *Corydalis*, etc.

The precoxale shows an interesting transition in the prothorax of sawflies. In *Abia* and also *Cimbex*, the episternum and sternum are connected by the precoxale (Fig. 15, pc). The latter is in the process of disappearing in *Dolerus* and is represented by a small sclerite on either side of the sternum (Fig. 12, pc). These small sclerites are not connected with either the sternum or episternum, but lie half way between them. In *Macroxyela* all trace of the precoxale is lost (Fig. 14). There is no indication of the connecting bridge between episternum and sternum, but the sternum is larger than in *Dolerus* or *Abia* and probably represents the fusion product of a part of the precoxale and sternum (Fig. 14, vs).

The terminology of the above discussed sclerites is somewhat confused. The precoxale was termed "laterale" by Crampton, '09 and "precoxal bridge" or "precoxale" by Crampton, '14. The pleurocoxale was termed "katopleura" by Verhoeff, '03, in the Forficulidæ, and in the Blattidæ he applies the same term to an entirely different sclerite, showing that his homologies of the thoracic sclerites are evidently incorrect. It was termed "episternal laterale" by Crampton, '09, and "lateropleurite" by Crampton, '14. The sternocoxale was termed "vorplatte," by Verhoeff, '03, "sternal laterale" by Crampton, '09, and "laterosternite" by Crampton, '14.

In introducing the terms pleurocoxale and sternocoxale, an effort has been made to improve the terminology of these sclerites. They are more or less closely associated with the precoxale and antecoxale of Crampton, '14, and all are situated near the base of the coxa. Hence the sclerites composing this region have been given a uniform ending, which with the prefix, denotes quite accurately the respective positions of these sclerites. The term trochantin is so widely known, accepted and used that it would not be advisable to change it. This, however, does not apply to the other sclerites mentioned above.

TROCHANTIN. The trochantin is a more or less triangular shaped sclerite situated at the base of the coxa (Fig. 3, tn_1). It varies in size being quite large in some insects (*Periplaneta*, Fig. 3, tn_2) and small in other forms. (*Tipula*, *Capnia*, *etc.*, Fig. 4, tn_1). In some forms, such as in the prothorax of *Periplaneta*, *Capnia*, etc., the basal portion of the trochantin is fused for a short distance with the episternum (Fig. 3, tn_1). In other insects it is partially or completely fused with the episternum and precoxale or else has disappeared. These various conditions of the trochantin are illustrated in such insects as *Corydalis*, *Capnia*, some Orthoptera, Trichoptera, Diptera, Coleoptera, etc. When the trochantin is present and not completely fused with other sclerites, it always articulates with the coxa.

In the prothorax of *Periplaneta* the trochantin has become transversely split into two sclerites, the upper and larger of which has been termed trochantinus major (Crampton, '09) (Fig. 3, tnm), and the lower and smaller the trochantinelle (Crampton, '14) (Fig. 3, tnl). Other writers consider the trochantinelle as the entire trochantin, but this is a mistake as one can readily see by comparing the trochantin of the prothorax with that of the meso- and metathorax, in which it is not divided transversely into two sclerites. The end of the trochantin which articulates with the coxa is constant in position in all three thoracic segments and bears at its extremity a small inward projecting process (Fig. 3, atn). In the prothoracic segment the trochantin is fused with the episternum for a short distance and is separated from the rest of the episternum and antecoxale, partly by suture and partly by membrane (Fig. 3, tn_1). In the meso- and metathorax, the trochantin is entirely marked off from the episternum and antecoxale by membrane (Fig. 3, tn_2).

In *Periplaneta*, the trochantin also has a distinct, heavy, longitudinal suture, dividing it into an anterior and posterior region, termed ante-trochantin and post-trochantin (Crampton, '14) respectively (Fig. 3, atn, ptn). This suture occurs in the trochantin of the pro-, meso-, and metathorax of the roach and can be plainly seen. In the prothorax (Fig. 3, tn_1) where the trochantin is divided into two sclerites, this longitudinal suture extends through both, thus showing that these two sclerites are equivalent to the sclerites in the meso- and metathorax which everyone admits is the entire trochantin.

In the mesothorax of *Corydalis* the trochantin is partly fused with the episternum and antecoxale. A part of it which corresponds to at least a portion of the trochantinelle, projects free and is partly constricted off from the rest of the trochantin (Fig. 10, tnl). This would indicate that the trochantinelle in the prothorax of *Periplaneta* is a detached portion of the trochantin. In *Corydalis* the portion of the trochantin which projects free is also divided longitudinally by a suture into an anterior and posterior region (Fig. 10, tnl). It articulates with the coxa and has an inward projecting process at its extremity. These features are also present in the trochantin of *Periplaneta*.

The trochantin of the pro- and metathorax in *Forficula*, assumes the shape of a triangle (Fig. 8, tn_1, tn_3). This sclerite may be the entire trochantin or it may be the fusion product of the trochantin and part of some other sclerite such as the precoxale or antecoxale. In the mesothorax there are three small sclerites between the trochantin and the coxa, one of which is probably a detached portion of the coxa and the others of the trochantin (Fig. 8, tn_2).

Sharp, '95, in discussing the thorax of insects (Camb. Nat. Hist. vol. V, pp. 222) figures the base of the front leg and part of the prothorax of *Blabera gigantea*. He finds the homologies of the thoracic sclerites difficult to determine and his figure is wrongly labeled. The region marked "epimeron" is a part of the trochantin; the "fold of the pronotun" is the epimeron and the sclerite he has termed the trochantin is only a part of the trochantin, viz., the trochantinelle.

Packard, '98, terms the meron the "trochantin." Jordan, '02, terms a small sclerite lying along the anterior margin of the coxa, the "trochantin." Comstock, '02, termed the post-trochantin the "trochantin;" the ante-trochantin, the "first antecoxal piece," and the antecoxale, the "second antecoxal piece." Berlese, '06, terms the trochantin the "subcoxa." Snodgrass, '09, Verhoeff, '02-'04, and others have termed the trochantinelle, the entire trochantin. Crampton, '09, used the term, "trochantinus minor," to designate the trochantinelle and the terms "coxal trochantin" and "antecoxal trochantin" to designate the post- and ante-trochantin.

COXA. The coxa is the basal segment of the leg and the only one, which it will be necessary to consider in this paper. It varies greatly in size and shape in different insects, but is always constant in position and serves as a landmark in homologizing the thoracic sclerites. In some forms it is undivided and in others it is composed of two or more pieces (Fig. 8, cx_3). It articulates with the coxal process and with the trochantin when the latter is present.

In *Periplaneta, Corydalis, Dictyophora,* etc., a narrow, heavily chitinized area is marked off by a suture along the anterior margin of the coxa (Fig. 10, cm). Crampton, '09, termed this region the "Coximarginal sclerite." There is also found in some insects a small sclerite with an inward projecting process, which is free, absent or attached to the anterior margin of the coxa, and is comparatively unimportant.

A glance at the coxa of the meso- and metathorax of *Periplaneta* will show that it is partly divided into an anterior and posterior region (Fig. 3, m. vcx). The posterior region will be termed the meron (Walton, '00) and the anterior, the veracoxa (Crampton '14). The suture which marks the divisions of the coxa, is apparently a continuation of the pleural suture. In *Periplaneta* the meron is partly fused with the coxa and partly divided from it by a suture (Fig. 3, m). The meron when present appears to be developed in the meso- and sometimes in the metathorax. I have never observed its presence in the prothorax and in some Diptera it is absent in the pro- and metathorax. Hence the development of the meron may possibly have some connection with the development of the wings. The coxa was probably originally one undivided sclerite and the meron has been derived from it secondarily. Where the meron does not occur, the coxa probably represents a persistent primitive condition, such as frequently occurs in insects.

In some insects the meron is completely marked off from the coxa by a suture (Fig. 4, m) and in many forms such as Diptera, it has become drawn upward or enlarged, so that it extends into the epimeral region and is often fused with the epimeron (Figs. 1, and 2, m). This has led to its misinterpretation in the Diptera by Snodgrass, '09, and others, who have considered it to be part of the sternum. The meron is separated from the sternum by membrane in such insects as *Tabanus, Tipula,* etc., and the sternum can be plainly seen to extend behind the meron (Fig. 11, msst).

Snodgrass, '09, considered the meron as derived from the epimeron. In the larva of *Corydalis,* he finds the epimeron marked off into an upper and lower region. In the pupal stage he finds that the lower portion of the epimeron has extended behind the coxa and partly fused with it. In the adult, he finds this region has fused entirely with the coxa and is separated from the epimeron by membrane. He also finds similar conditions in the larval, pupal and adult stages of Trichoptera. It seems more probable however, that the meron is part of the coxa and derived from it, as the condition found in the roach plainly indicates. The roach is also a more primitive insect than the Trichoptera, etc. In some insects (*Tipula*, *Mantispa*, etc.) the epimeron is divided into an upper and lower region and the meron is also present. This would probably not be the case if the meron were equivalent to the lower portion of the epimeron (Figs. 1 and 13, m).

The position of the coxa in its various relations to the other parts of the thorax in different insects, has led to the formulation of various theories from time to time.

Thus Miall and Denny, '86, from a study of the roach, concluded that the sclerites at the base of the leg, represent two basal leg joints, which became attached to the thorax.

Heymons, '99, in his studies on *Nepa* designated the sclerites at the base of the leg (episternum, precoxale, etc.) as the "subcoxa," and adopted Miall and Denny's view, that this region represents the basal portion of the leg.

Several writers including Hansen, Jourdain, Börner and Henneguy, have compared the styli found on the meso- and metathoracic coxæ in certain insects, to parts (exopodite, epipodite, etc.) of the crustacean leg. Banks, '93, considered the styli as vestigial legs and Verhoeff, '02–'04, regarded them as homologous with the coxal organs of Myriopoda.

Walton, '00, considered the meron as a vestigial leg, but has since retracted this statement.

Most of the above mentioned theories have already been discussed under the heading, Historical Review, and it will not be necessary to consider them further here.

Sternum. The term sternum was originally applied to the whole ventral surface of any thoracic segment and is everywhere used in this sense. This, of course, prohibits the use of the term sternum for a subdivision of itself, although several writers have used it in both senses and thus have allowed opportunity for more or less confusion.

The sternum is probably composed of five subdivisions, which vary greatly in size and shape in different insects. In some Hymenoptera and Coleoptera they are all fused into one sclerite. Three of these subdivisions are usually present in most insects, while the other two occur in only a few. For these sclerites, I shall use a modification of Crampton's '09, terminology, designating the subdivisions of the sternum as sternites. Thus as far as possible, without leading to confusion, the subdivisions of the tergum, pleuron and sternum will be designated by the endings tergite, pleurite, and sternite respectively.

The presternite (Fig. 4, prs_1), or anterior division of the sternum is derived from the verasternite ("sternum" or "basisternum" of other writers) and is absent in most insects. In the prothorax of *Ectobia lapponica* the presternite is in the process of becoming detached from the verasternite (Fig. 9, prs). In the prothorax of *Capnia* it is completely detached from the verasternite and lies directly in front of it (Fig. 4, prs_1). It is quite a large, oblong sclerite and has frequently been mistaken for one of the neck sclerites, owing to its position. The presternite is also found in the meso- and metathorax of *Capnia* (Fig. 4, prs_2, prs_3) and in the prothorax of *Forficula* (Fig. 8, prs). The presternite is also present in *Raphidia* and has been figured in the metathorax of *Pteronarcys* by Comstock and Kochi, '02. In the latter insect it is similar in shape to the presternite of the prothorax of *Ectobia lapponica* and is attached to the verasternite in the same manner. Comstock and Kochi, '02, have termed it the "presternum." In all other insects examined, the presternite is either absent or indistinguishably fused with the verasternite.

The verasternite is a large sclerite of variable shape lying immediately posterior to the presternite, when the latter is present (Fig. 8, vs_1). It is found in all insects and is often fused at its anterior corners with the precoxale, thereby forming the connecting bridge between the episternum and sternum (Fig. 7, vs_1). In such insects as the Lepidoptera, Diptera, etc., the verasternite is divided longitudinally by a median groove formed by an infolding of the chitin (Fig. 14, vs). Internally this groove is represented by a longitudinal, chitinous ridge. In *Ectobia* the verasternite is divided diagonally by two sutures into four sclerites and the precoxale is not fused with it (Fig. 9, vs).

The furcasternite is situated directly behind the verasternite and is usually a much smaller sclerite, although quite variable in shape in different insects (Fig. 7, fs). It is usually fused with the verasternite, but may be detached as in the prothorax of *Periplaneta* (Fig. 3, fs_1). In insects where fusion of the furca- and verasternite occurs, the former is often divided longitudinally by the median groove, exactly as in the verasternite (Fig. 14, fs). This median infolding of the integument does not occur in primitive insects and is probably a secondary modification of the more specialized forms.

Internally the furcasternite bears two processes or furca. These are usually hollow, strongly chitinized apophyses and are always present (Fig. 3, f). The furcal arms usually abut against the apodemes (pleural arms) and very frequently are closely united with them, thus forming a strong internal connection between the pleuron and sternum.

Externally the furcasternite is easily distinguished, even when fused with the verasternite. Sometimes in such insects as *Capnia*, it is connected with the epimeron (Fig. 4, fs_1). This is brought about by a narrow sclerite (postepimeron), which extends from the epimeron behind the coxa and joins the furcasternite, thus forming a connecting bridge. When the precoxale and verasternite are also fused, a complete ring is formed inclosing the coxa.

The pleural suture, together with the suture which extends between the veracoxa and meron and the one which separates the furca and verasternite, present a condition which has given rise to several double segment theories, but it does not necessarily follow that these sutures mark a division between two segments, as previously discussed.

The furcasternite in the prothorax of *Periplaneta* is a single, transverse, oval sclerite (Fig. 3, fs_1). In the meso- and metathorax it is Y shaped and fused with the verasternite (Fig. 3, fs_2, fs_3). In some forms it is also fused with the spinasternite (discussed later) as in some Lepidoptera, etc., while in others, such as in the prothorax of *Leuctra*, it is divided into two sclerites. Thus there are a few modifications in different insects.

There are indications of a fourth division of the sternum in a few insects, but it is usually absent. In the prothorax of *Capnia*, it is a single, large, oval sclerite, lying behind the furcasternite (Fig. 4, pfs_1). In *Leuctra* this sclerite is divided longitudinally into two small sclerites. In *Periplaneta* the fourth division or postfurcasternite, is probably represented by two small sclerites on either side of and behind the furcasternite. (Fig. 3, pfs_1).

The spinasternite or fifth division is generally present and usually quite small and variable in shape (Fig. 3, ss). It bears a single internal apophyses, the spina, which is usually hollow. This sclerite lies behind the postfurcasternite, when the latter is present and behind the furcasternite when it is absent. The spinasternite in some insects is free or attached to the mesothoracic verasternite. In others it is either united or fused with the furcasternite. It is so variable in position that it is very hard to tell to which segment the spinasternite belongs, but it probably belongs to the segment in front of it, as no spinasternite has ever been described as occuring in front of the prothoracic verasternite. In the prothorax of *Corydalis*, *Forficula*, etc., it is very small, being represented by the internal apophyses only (Fig. 8, ss_1).

Audouin, '24, applied the term sternum to the entire ventral surface of any thoracic segment. It has since been used to designate various subdivisions of the sternum by different authors and this has naturally led to some confusion.

Mac Leay, '30, thought that each thoracic segment was composed of four subsegments and hence assumed that the sternum was composed of four subdivisions. He accordingly proposed the terms praesternum, sternum, sternellum and poststernellum for these supposed subdivisions.

Newport, '39, adopted Mac Leay's views, but was unable to find four subdivisions in the sternum of any living insect. Mac Leay's terminology, however, has been used by several writers.

Crampton, '09, used the terms presternum, basisternum, furcisternum, postfurcal sclerite and spinasternum, each sclerite being named after some characteristic which it bears. I have adopted this terminology in a slightly modified form, using the prefixes (except "basi") with sternite, to denote the subdivisions of the sternum.

Comstock and Kochi, '02, in their figures of the metathorax of *Pteronarcys* and *Stenopelmatus*, have labeled the first abdominal segment the "sternellum." In their figures of the neck plates of *Gryllus*, *Periplaneta*, etc., they have designated the posterior ventral cervical sclerite the "sternellum." Consequently it is impossible to decide to what sclerite they intend the term "sternellum" to be applied.

Snodgrass, '09, used Mac Leay's terminology for the sternum, but later he used the term "eusternum" instead of "sternum," to designate the verasternite, or second division of the sternum. Snodgrass, '09, however, found and named only three subdivisions of the sternum, the presternum, sternum and sternellum. The assumed poststernellum of Mac Leay is neither figured nor mentioned. His claim that the presternum consists of two plates and that it is equivalent to the "vorplatten" of German entomologists is incorrect. The presternum consists of only one plate in all insects in which it has been found and the "vorplatten" are parts of the precoxale. Furthermore in his figures, the true presternum is not shown, but in each case some other part of the sternum is designated as the presternum.

Berlese, '06, considered the whole thoracic sternum as composed of the pro-, acro-, meso- and metasternites. He found that each of the latter was divided into two sclerites, which he termed the "sterni" and "sternelli." These subdivisions (sterni and sternelli) are incorrectly homologized in the different insects figured in his work. He has interpreted the "sternelli" as the spinasternite, as the first abdominal segment, as the spinasternite plus the furcasternite, as the verasternite, etc. Hence his interpretations of the sclerites are so inconsistent in his figures, that it is impossible to tell what sclerite he intends to designate by his "sterni" and "sternelli."

INTERSEGMENTALIA. Between the thoracic segments in such insects as the Orthoptera, Plecoptera, Trichoptera, Neuroptera, etc., there are usually a few small sclerites (Fig. 4, i). These vary in number, size and shape in different insects and include the plates surrounding the spiracle when the latter is present. They have been appropriately termed the intersegmentalia (Crampton, '09) because they are situated in the intersegmental membrane.

The intersegmentalia may be either detached portions of the segment in front of them, of the segment behind them, or of both. Which supposition is correct it is impossible to say, without first working out the musculature of these sclerites. Whether the spiracle belongs to the segment in front, or behind it, is still a disputed question, although it seems very probable that each spiracle belongs to the segment behind it.

In the dorsal neck region of *Periplaneta* there is a small sclerite (Fig. 5, dcs), which seems to be homologous with a similar sclerite found in the dorsal intersegmental region between the pro- and mesothorax of *Corydalis* (Fig. 6, i). This would indicate that the neck sclerites and the intersegmentalia are homologous.

Voss, '04, Heymons, '95, and Palmén, '77, have proposed various theories concerning the spiracles. From a study of the musculature, Voss, '04, claims that they belong to the segment in front of them. From a study of their embryology, Heymons, '95, concluded that they lie in the anterior portion of their respective segments, but may secondarily move forward and become attached to the segment in front of them. Palmén, '77, thought that the first thoracic spiracle might be either pro- or mesothoracic, varying in different insects. It is generally agreed among most workers that the third thoracic spiracle belongs to the first abdominal segment. Of the three theories mentioned, Heymons' seems to have the most support, but more investigation on this point is necessary before it can be definitely settled.

CERVICAL SCLERITES. Embedded in the soft neck region of most insects are found a varying number of sclerites, differing in size and shape in different insects (Fig. 3, 1cs, vcs). These sclerites are designated by the term "Cervical Sclerites" (Huxley, '85) or "microthoracic sclerites" (Verhoeff, '02-'04), etc. In this paper the term cervical sclerites will be adopted for these neck plates.

There can be no question that the cervical sclerites of one insect are in general homologous with the cervicals of other insects. But difficulty arises as to the origin of these neck plates and their homologies. They may be either detached portions of the head or of the prothorax or of both, while some have even considered them as the remains of one or more primitive segments. Each of these four theories has its own adherents and which one is correct, it is impossible to say at present. The cervical sclerites furnish support for the head and it appears very probable that they are detached portions of both the head and prothorax. In some forms such as *Forficula*, *Dolerus*, etc., the lateral cervical bears an inward projecting process (Fig. 14, ap).

In *Periplaneta* there are two large lateral cervicals on either side of the neck and two ventral cervicals (Fig. 3, lcs, vcs). The lateral sclerites articulate with the head and prothoracic precoxale. This is true of all insects where the lateral cervicals occur except when they are fused with the precoxale and episternum (Fig. 7, lcs). In the latter case they articulate with the head alone (Fig. 12, lcs). The lateral cervical sclerites in *Periplaneta* articulate with small sclerites attached to the head as shown in (Fig. 3, a). The lateral cervicals very nearly meet in front of the prothoracic verasternite in *Periplaneta* (Fig. 3, lcs). The lateral cervical sclerites in *Gryllus* consist of one large plate on either side of the neck, which probably represents the fusion product of the two lateral sclerites found in the roach and other insects (Fig. 7, lcs). The two ventral sclerites in the roach, have evidently become split into five small sclerites in *Gryllus* (Fig. 7, vcs).

There is only one ventral cervical sclerite in *Forficula* and *Capnia*, the other having disappeared, while the lateral cervicals in the former are more numerous than in the latter (Figs. 8 and 4). Both of these insects have a large, more or less oval sclerite situated directly in front of the prothoracic verasternite (Figs. 8 and 4, prs), which has been mistaken by several writers for a cervical sclerite. This sclerite is in reality the presternite, which has become detached from the verasternite. In the prothorax of the roach *Ectobia lapponica*, the presternite is seen in the process of becoming detached (Fig. 9, prs). It has been found, however, in only a few insects.

The cervical sclerites are quite numerous in the lower insects such as *Periplaneta*, *Gryllus*, etc. (Figs. 3 and 7). In the higher insects (Neuroptera, Lepidoptera, Diptera, etc.), there is a tendency for the cervical sclerites to fuse together and increase in size, which becomes more marked in the more specialized forms (Fig. 2, lcs). The cervical sclerites in many Coleoptera have disappeared or have become indistinguishably fused with the prothoracic plates. In some Hymenoptera (Tenthredinidæ) the lateral cervicals have become fused with the prothoracic episternum (Fig. 12, lcs).

Snodgrass, '10, from a study of the Hymenopteron thorax, concluded that the large sclerite which lies in front of the coxa and "prosternum" (prothoracic verasternite) of sawflies, was the "proepisternum" (Fig. 15, lcs). He bases his claim upon the position of the pleural suture. A small sclerite which adjoins the "proepisternum" dorsally in *Dolerus*, he admits is a cervical sclerite (Fig. 12, lcs). The conclusions reached by Snodgrass, '10, appear incorrect for several reasons. It is more probable that the conditions found in the prothorax of sawflies, is the result of a fusion of the cervical sclerites with the episternum, in which the cervicals have become enlarged and the episternum and epimeron have become greatly reduced in size. The fusion and enlargement of the cervicals is very noticeable in the higher insects (Tipulidæ) while a reduction of the episternum and epimeron is found in practically all insects. Furthermore, the episternum never meets in front of the prothoracic verasternite and never articulates with the head, as do the cervical sclerites and also the "proepisternum" of Snodgrass, '10, in the sawflies.

A more conclusive proof that sawflies have a large lateral cervical may be obtained from a study of *Abia*, *Dolerus*, and *Macroxyela* in the order named. In the prothorax of *Abia* the precoxale or bridge which connects the episternum with the verasternite in a large number of insects can be plainly seen (Fig. 15, pc). It extends from the coxal process to the verasternite, thereby connecting the episternum and verasternite. The episternum has never been known to occur in front of the precoxale, but the cervical sclerites are always situated anterior to it. The large sclerite which lies in front of the coxa and the "proepisternum," also lies in front of the precoxale. Hence this sclerite cannot be the prothoracic episternum, or "proepisternum," but must be a lateral cervical sclerite. In *Dolerus* the precoxale is in the process of disappearing (Fig. 12, pc). It is represented on either side of the prothoracic verasternite by a small sclerite (Fig. 12, pc), while in *Macroxyela* it has entirely disappeared (Fig. 14), In the latter insect however, the verasternite has greatly increased in size and may possibly represent the fusion product of the verasternite and part of the precoxale (Fig. 14, vs). A cleft indicating a possible splitting of the lateral cervical is seen in *Macroxyela* (Fig. 14). The episternum and epimeron are clearly marked off by sutures in the prothorax of *Dolerus* and are seen to be much reduced in size (Fig. 12, es, em_1). From the above facts, it seems very probable that the large sclerite in sawflies, which Snodgrass, '10, calls the "proepisternum," is really a large lateral cervical sclerite, fused with the episternum and in some cases with the epimeron also. The fact that an internal process is present at the point of articulation of the "proepisternum" with the head (Fig. 15, ap), signifies that this plate is a cervical sclerite, since a similar process is found on the lateral cervicals of several other insects as in *Gryllus*, *Forficula*, etc.

When the epimeron is absent in the prothorax of sawflies, Snodgrass, '10, considers the internal process or pleural arm, as apparently not the homologue of the pleural arm of the other segments, since it does not arise between the plates (Fig. 14, pla). This may be true, but in all cases the pleural arm is joined to the furca of the furcasternite as in other segments and in other insects. If the epimeron has apparently disappeared in the prothorax of some sawflies, it may be represented by a part of the pleural arm itself, especially if it be true that the pleural arm is formed by an infolding of the integument. Thus it would seem more probable that the pleural arm in the prothorax of sawflies, in which the epimeron is absent, is the homologue of the pleural arm of other segments and of other insects.

Several theories have been formulated to account for the origin of the cervical sclerites.

Straus-Durckheim, '28, suggested that the cervical sclerites represent the remains of two segments, situated originally between the head and prothorax. He designated them by the term "pieces jugulaire."

Newport, '39, considered them as detached portions of the prothorax and called them the prothoracic "paraptera."

Lowne, '70, regarded the cervicals as a part of the labial segment or last cephalic segment of the head. This theory was later adopted and supported by Huxley, '85, Comstock, '02, Riley, '04 and others. Although Riley, '04, regards the lateral cervical sclerites as the pleurites of the labial segment of the head, he also states that part of the pleural region of the labial segment is already included in the head capsule. Lowne, '70, applied the terms "condyle" to the lateral cervicals and "cephlo-sternum" to the ventral cervicals. Huxley, '85, used the term cervical sclerites to designate the neck plates.

Lowne, '90, considered the cervicals as detached portions of the prothorax, thereby accepting the theory formerly proposed by Newport, '39.

Verhoeff, '02-'04, adopted and elaborated the theory advanced by Straus-Durckheim, '28, viz., that the cervicals represent two segments originally situated between the head and prothorax. He termed the neck region the "microthorax" and designated the various sclerites by the terms, "coxopleure," "anapleure," etc. This theory was severely criticized by Silvestri, '02, Börner, '03, Voss, '04, Desguin, '08, and others. They proved conclusively that Verhoeff's "microthoracic" theory was unsupported by anatomy, embryology, musculature, etc.

Berlese, '06, regarded the cervical sclerites as belonging to the head and prothorax.

Snodgrass, '08, adopted Verhoeff's theory of the "microthorax," but later Snodgrass, '09, repudiates the "microthoracic" theory, adopting the term "cervicum" of Crampton, '09, for the neck region.

SUMMARY.

The thorax is composed of three segments, the pro-, meso-, and metathorax.

All compound segment theories are not based upon enough facts to be acceptable at present.

The thorax of primitive insects, larvae, etc., is composed of numerous small sclerites, which become fused to form the sclerites of the higher insects.

A secondary fusion or a splitting of sclerites often occurs. Certain specialized forms often retain some characters of primitive insects.

The tergum of winged insects is composed of two sclerites, which are usually subdivided into regions.

The wing articulates with two processes on the lateral margin of the tergum and with the alar plates at the base of the wing. Ventrally it articulates with the pleural wing process.

The pleuron is represented by a single sclerite in some primitive insects. (*Eosentomon*).

The pleural suture is always present, together with the apodeme, and they are probably formed by the infolding of the integument due to muscular stress or similar causes.

The pleuron may be connected dorsally with the tergum at its anterior and posterior end by a bridge and ventrally with the sternum in a similar manner.

The episternum and epimeron are subdivided into an upper and lower region in some insects. (*Mantispa*).

The sternum is composed of five subdivisions in a few insects. (*Capnia*, *Ectobia*, etc.)

The presternite is present as a large, oval sclerite, lying in front of the prothoracic verasternite in *Capnia* and *Forficula*. It is considered as a large ventral cervical by most writers.

The large sclerite which lies in front of the coxa in the prothorax of sawflies, is largely composed of the lateral cervical, fused with the episternum, and in some cases with the epimeron also.

The cervical sclerites are detached portions of the head and prothorax and are homologous with the intersegmentalia, which are probably derived from the segments directly anterior and posterior to them.

In some insects the coxa is composed of two parts, the meron or posterior portion and the veracoxa or anterior portion. The meron is part of the coxa and derived from it.

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TERMINOLOGY.

The sub-figures 1, 2, and 3 indicate that the sclerites belong to the pro-, meso- and metathorax respectively.

a—sclerite attached to base of head in Periplaneta.
aba—anterior basalar.
ac—antecoxale.
ad—apodeme.
ap—apophysis.
atn—antetrochantin.
ba—basalar sclerites.
cm—coximarginal sclerite.
cs—cervical sclerite.
cx—coxa.
cxp—coxal process.
dcs—dorsal cervical slcerite.
el—elytra.
em—epimeron.
es—episternum.
esp—anepisternum.
f—furca.
fs—furcasternite.
g—suture dividing episternum into two regions.
h—halteres.
i—intersegmentalia.
inplt—inner pleurotergite.
iplt—inferior pleurotergite.
kem—katepimeron.
lcs—lateral cervical sclerite.
m—meron.
mp—meropleurite.
msn—mesonotum.
msst—mesosternum.
mt—mediotergite.
mtn—metanotum.
mtst—metasternum.
o—suture dividing episternum and precoxale in *Periplaneta.*
oplt—outer pleurotergite.
pba—posterior basalar sclerite.
pc—precoxale.
pem—postepimeron.
pes—pre-episternum.
pfs—postfurcasternite.
pla—pleural arm.
plc—pleurocoxale.
pls—pleural suture.
plt—pleurotergite.
pltn—pleurotrochantin.
plwp—pleural wing process.
pn—pronotum.
prs—presternite.
prsc—prescutum.
psl—postscutellum.
ptn—post-trochantin.
ptp—pteropleurite.
sa—subalar sclerite.
sc—scutum.
scsl—scutoscutellum.
sl—scutellum.
sp—spiracle.
spa—abdominal spiracle.
spplt—superior pleurotergite.
ss—spinasternite.
stc—sternocoxale.
stp—sternopleurite.
tm—tergum.
tn—trochantin.
tnl—trochantinelle.
tnm—trochantin major.
vcs—ventral cervical sclerites.
vcx—veracoxa.
vs—verasternite.
w—wings.
1st a—1st abdominal segment.

EXPLANATION OF PLATES.

Owing to the nature of the thorax, the figures are necessarily somewhat diagramatic, but as far as possible, represent the natural condition of the sclerites as they occur in the thorax of these insects. In lateral views the anterior end faces the right side of the page. In ventral and dorsal views the anterior end faces the top of the page.

PLATE I.

Fig. 1. A lateral view of the thorax of *Tipula,* including part of the dorsum and the first abdominal segment. Head, wing and the greater part of each leg removed.

Fig. 2. A lateral view of the thorax of *Leptis,* including part of the dorsum and the first abdominal segment. Head, wing and the greater part of each leg removed.

PLATE II.

Fig. 3. A three-quarters view of the thorax of *Periplaneta,* showing the ventral and lateral sclerites, together with the edge of the pronotum and wings. Head and the greater part of each leg removed.

Fig. 4. A three-quarters view of the thorax of *Capnia,* showing the ventral and lateral sclerites, together with the edge of the pronotum and wings. Head and the greater part of each leg removed.

Fig. 5. Dorsal cervical sclerites of *Periplaneta.*

Fig. 6. Dorsal intersegmentalia, occurring between the pro- and mesothorax of *Corydalis.*

PLATE III.

Fig. 7. A three-quarters view of the thorax of *Gryllus* including the lateral and ventral sclerites, together with the edge of the pronotum and wings. Head and greater part of each leg removed.

Fig. 8. A three-quarters view of the thorax of *Forficula,* including the lateral and ventral sclerites and the edge of the pronotum and wings. Head and greater part of each leg removed.

Fig. 9. A three-quarters view of the prothorax of *Ectobia lapponica,* including the ventral and lateral sclerites, and the edge of the pronotum. Head and greater part of each leg removed.

Fig. 10. A lateral view of the mesothorax of *Corydalis,* including part of the tergum and sternum. Most of the leg removed.

PLATE IV.

Fig. 11. A lateral view of the thorax of *Tabanus,* including part of the dorsum. Head, wing and the greater part of each leg removed.

Fig. 12. Ventral view of the prothorax of *Dolerus,* showing ventral and lateral sclerites. Head and greater part of each leg removed.

Fig. 13. Lateral view of the thorax of *Chrysopa* including part of dorsum and first abdominal segment. Head, wing and greater part of each leg removed.

Fig. 14. A ventral view of the prothorax of *Macroxyela,* showing ventral and lateral sclerites. Head and most of each leg removed.

Fig. 15. Ventral view of the prothorax of *Abia,* showing ventral and lateral sclerites. Head and most of each leg removed.

Fig. 1

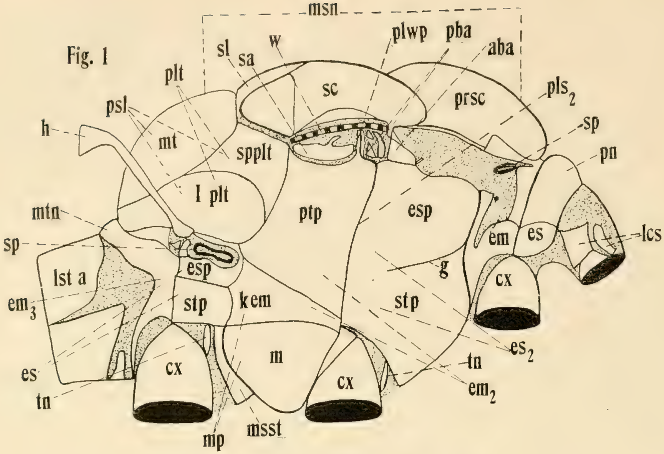

Fig. 2

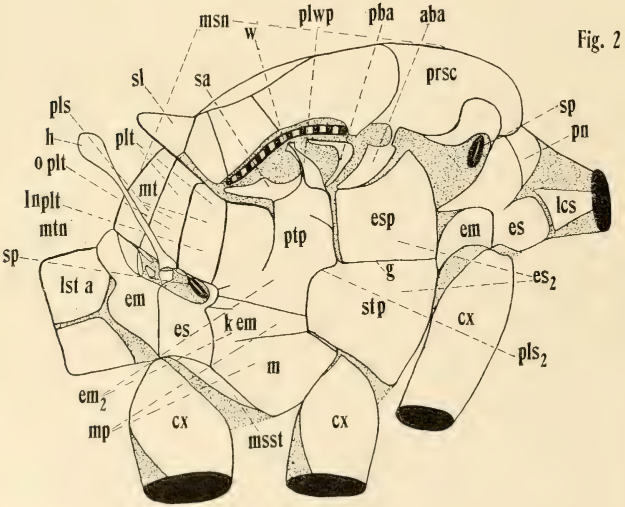

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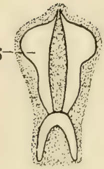
Fig. 5



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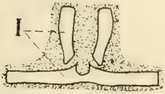

Fig. 3

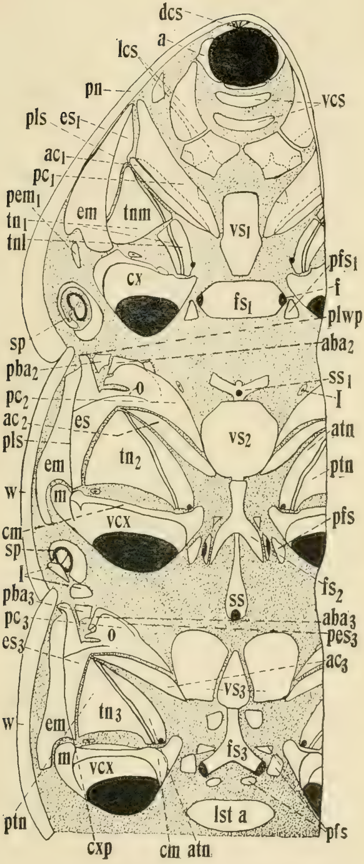

Fig. 4

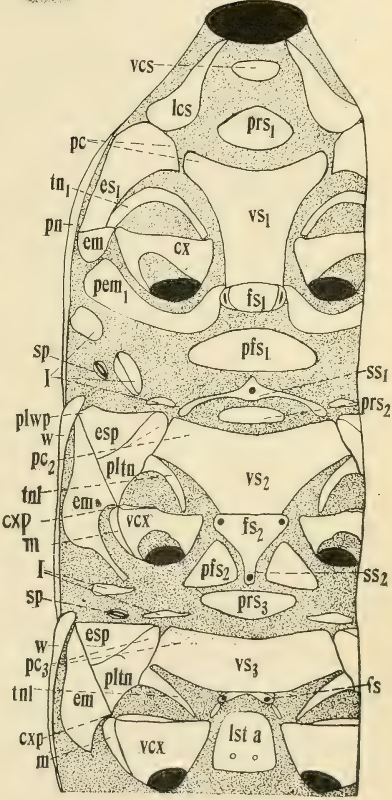

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Fig. 7

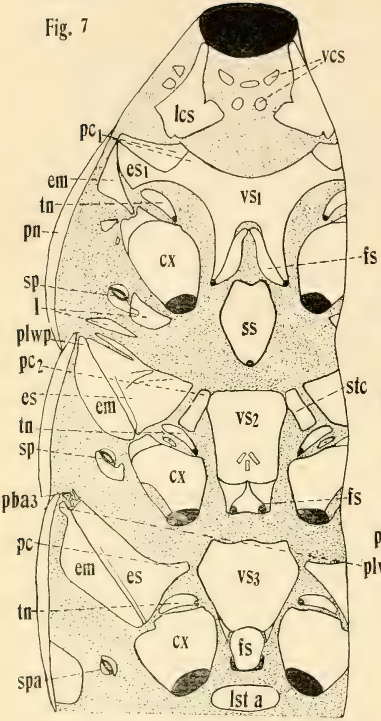


Fig. 8

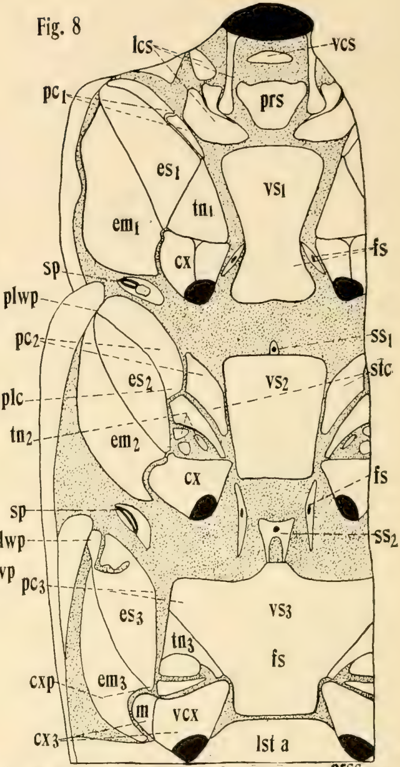


Fig. 9

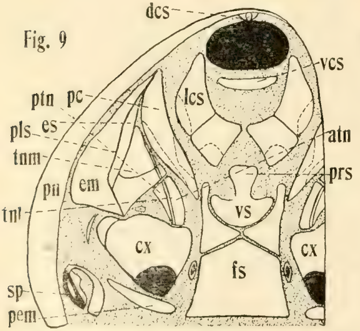
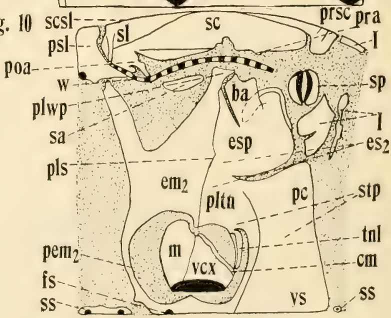


Fig. 10



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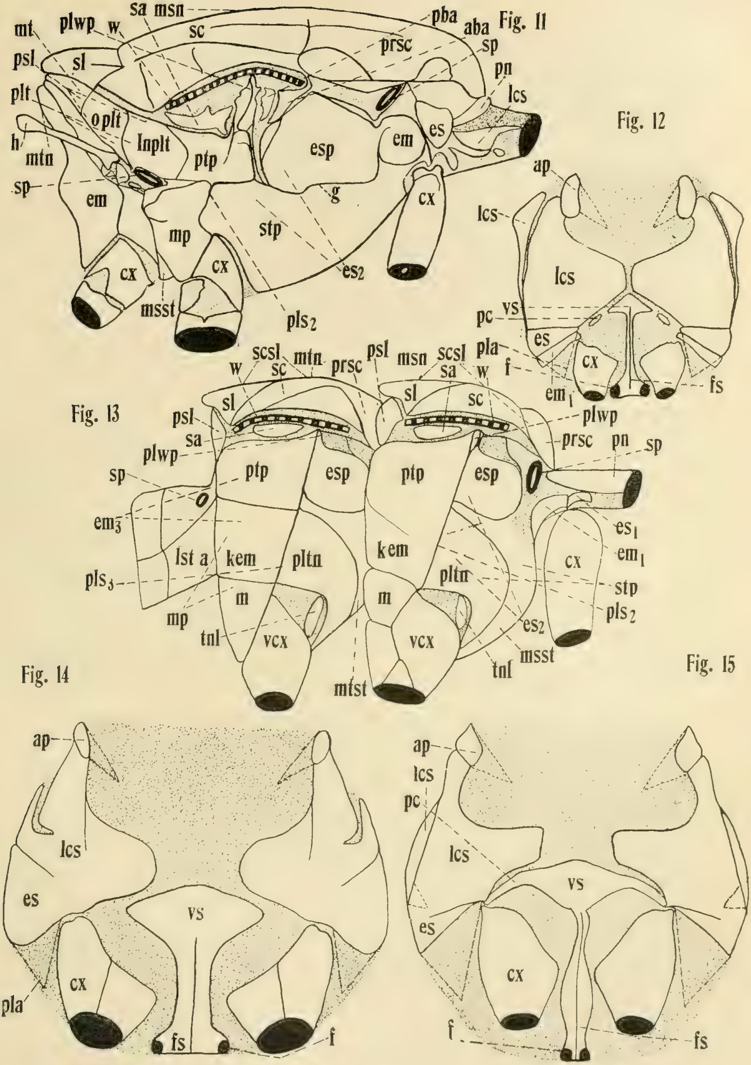

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

J. F. Martin.

PRIORITY IN FAMILY NAMES AND RELATED MATTERS.

By E. P. Van Duzee,*
University of California, Berkeley, Cal.

What would we say if some iconoclast in nomenclature should promulgate the dictum that the type of each genus must be the earliest described species now included in that genus? But when we stop to think of it that would be no more revolutionary than Kirkaldy's scheme to make the earliest described genus in each family the type genus of that family and when necessary to rename the family so it shall bear the name of such genus; a scheme, strange to say, that has had a considerable following among continental Hemipterists. Kirkaldy was led to his action through his efforts to restrict the limits of certain of the families of the earlier writers on Hemiptera and to use the names already applied for his new family concepts. Had he adopted instead the "historical method" used by him in naming genotypes and treated family names by the same rule he applied to generic names most of his difficulties would have vanished at once.

In 1911 Dr. Horvath gave us in outline his plan to apply the rule of priority to family names as it has long been applied in the case of generic and specific names. This it seems to me is the only logical way to treat family names. I can conceive of no argument against such a course that would not apply with equal force to the application of the rule of priority to the names of genera and species.

In working out the nomenclature of my Catalogue of North American Hemiptera I adopted Dr. Horvath's plan in its broader principles, changing a few details where its practical application developed weak points. I have become much interested in the results of my undertaking and thought it might not be inappropriate to lay before this Society an outline of the "rules" if such they might be called, for the formation and limitation of the names of families and other group names higher than genera, used by me in the preparation of this catalogue. In brief these are as follows:

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*Read before the Berkeley meeting of the Entomological Society of America, August 5th, 1915.

First. The name of each family must be derived from that of some included genus and such genus then automatically becomes the type of such family, and the family name must follow that of its type genus through all its mutations. Hence, if the name of the type genus is found to be preoccupied the family must take the new name applied to such genus and not the next oldest name used in the family, as that would virtually be changing the type and thus breaking down the very foundation of the plan.

Second. A family name cannot be rejected when the limits of the family are extended or restricted any more than in the case of a generic name. The family name merely means the group of genera related to the type genus be that group large or small.

Third. While desirable it is not essential that the name of a family as first founded be in the correct latin form. Colloquial names when formed from a valid generic name so as to indicate indubitably the type genus must be accepted. Similarly, a family name founded with a different termination or in a different category is to be accepted and its termination changed to bring it into accord with the International Rules. Hence, a subfamily or tribe may be raised to family rank by changing its termination to *idæ*.

Fourth. When two or more families are united the name having priority must stand. Page precedence must not be confounded with priority, it has little to do with nomenclature and should be applied only as a last resort.

Fifth. However desirable it is not essential to validity that the founding of a new family be accompanied by a description or even a summary of family characters. If the name be properly formed from that of a generic name that genus becomes its type and it is to consist of the genera related to that type genus. If characters are named and a later writer gives the family a wider or narrower scope he cannot rename it on the assumption that he has founded a new family.

Sixth. If a family be divided into subfamilies, tribes or divisions the section in each category containing the type genus must bear the name of that genus with the termination *inæ* for subfamilies, *ini* for tribes and *aria* for divisions. This is in accord with the International Committee's rule that in a genus divided into subgenera the one containing the type species shall bear the name of the genus.

So much for family names. I now wish to call attention to a few other points in nomenclature that have forced themselves upon me during the preparation of this catalogue.

First, and perhaps most important: What constitutes the founding of a genus? I have looked in vain in the International Rules for an answer to this question, but one conclusion seems incontrovertable: *No genus is valid until a type species can be named for it.* Thus a genus described without the mention of a species is invalid until a species is included in it and it must then date from the inclusion of such species, and must take for its author the one assigning the species.

Second. A genus founded without a description but with a definite statement or indication that it is founded on a certain species is valid if the species named has been properly described. If we refuse to accept such a generic name we must also refuse to accept a genus founded in connection with a species in a single description.

Third. A mere catalogue name is a *nomen nudum* and is invalid except in cases where it is perfectly evident that it was given to replace a preoccupied name, or a name cited in error.

Fourth. Emendations are not desirable except where there has been an obvious misprint or error in spelling. Thus I have restored to their original form most of the numerous names emended by Amyot and Serville.

Fifth. The selection of a genotype is a matter of great importance as in many cases a selection may change the meaning or scope of a genus. In my catalogue I have used the earliest type fixation known to me that does not conflict with the International Rules and common sense. Among the early writers it is sometimes difficult to be certain just what should be considered as type fixations. So far as I can discover Lamarck, in 1801, was the first to say he was indicating the type species in the Hemiptera. Fabricius certainly indicated type species for most of the genera in the Systema Rhyngotorum, in 1803, by repeating with italics the generic characters in his description of the type species. That this was his intention in repeating these generic characters we are informed by Fallen who was almost or quite a contemporary of Fabricius. Latreille in 1810 was the next to say he was naming types for the genera of the Hemiptera, followed by Laporte in 1832 and Westwood in 1840. Kirkaldy claims that Latreille in his work of 1802, in naming "examples" under each genus, was really naming types but I have been unable to accept this as he so obviously was selecting the species most likely to be known to those students living in France and did not restrict himself to them in his definite type fixations of 1810. Some of those early systematists named two types to a genus and in such cases I have followed Kirkaldy in rejecting both and taking the next valid fixation.

In the matter of species there is but one point I wish to bring out. As I understand the International Rules subgenera are placed on the same footing as genera and subspecies and varieties on the same footing as species. Hence, subgeneric names are preoccupied by generic, and subspecies and variety names are preoccupied by those of species, and vice versa. This principle has not been recognized in the Oshanin Catalogue but it is really essential that it be generally adopted on account of the frequency with which a form is shifted from one category to another.

Before closing, I wish to call attention to a matter that it seems to me is of prime importance and that is what I would call the validation of entomological literature. If you will take the trouble to look up the matter you will find that most of the changes in names come through different methods of selecting genotypes and through varying views regarding the validity of certain early papers. After we think we have the nomenclature of some group of insects well settled some one will dig up an ancient catalogue and discover there new names, generic and specific, and armed with these he will proceed to demolish our nomenclature. Our most crying need now is for a validated list of early books and papers, published, say, prior to 1850, and I would strongly urge that a committee be appointed, preferably by the International Zoological Congress, to go over the zoological bibliographies, which are now fairly complete, and decide which works are valid and which are mere catalogues or are too ephemeral to have a standing in zoological nomenclature. That we should discard mere catalogue names is I think irrefutable. Anyone who thinks otherwise will certainly be cured of this delusion if he will read Stephen's introduction to his Catalogue of 1829, where he says in effect that he does not care to take either the time or trouble to prepare descriptions of the numerous new genera he has established in his catalogue but will leave that task to anyone who feels inclined to undertake it, with the inference that it could be done by someone whose time is less valuable than his. I am sure no sane person would think of using Stephen's names after reading that preface, or perhaps I should say of crediting them to Stephens. If the Zoologists as a whole are not willing to undertake the preparation of such a validated bibliography I can see no reason why the entomologists should not do so independently. It would then be up to the Zoologists to endorse the list or to give their reasons for not doing so. What we most need now is stability and that we can never have while each individual entomologist is free to accept as valid or to reject as invalid the numerous uncertain papers and books that appeared in the early days of our science and may still be imminent.

A METHOD OF KEEPING ALCOHOLIC SPECIMENS.

By F. C. Bishopp,
Bureau of Entomology, U. S. Department of Agriculture.

The following method of preserving alcoholic specimens has been used at the Dallas laboratory for the Bureau of Entomology for a number of years. It has been found to be more satisfactory than any other system tried.

The specimens to be preserved are placed in the smallest size shell vials, which will contain the specimens, and a brief, finely printed label. For minute specimens, such as mites, mallophaga, etc., shell vials 25 mm. in length by 8 mm. in diameter are used. In fact, this size vial is employed for all specimens which can be placed in them without crushing. About three other sizes of shell vials are employed for the larger material. For short, thick specimens short vials of large diameter are used. The shell vials containing the specimens and labels are stopped with a small compact wad of absorbent cotton and the vials are then inverted and placed in a larger container. The container employed by us is a shell vial, 100 mm. long, by 28 mm. in diameter. A small layer of absorbent cotton is placed in the bottom of the container before the vials are inserted. This prevents danger of cracking the bottom when the small vials are dropped in. Each container is limited to one species, or if very little material of a certain kind is to be collected one of the large vials may contain a genus or even larger groups.

Ordinarily, however, each container is limited to a species, and a label bearing the name of the species is placed on the outside of the container, as is also the container number. Containers of the above diameter will hold conveniently seven or eight of the smallest size vials in one layer, and two layers may be placed in each. The container is then filled with alcohol in order to cover the vials and a good quality of cork used to close it. In the Dallas collection the material is then filed systematically by orders and alphabetically by genus and species under these. The containers are kept in wooden racks sufficiently wide to hold two of the bottles with a partition between and twelve inches long. A label is placed on the end of the rack to show the material it contains, and cardboard riders are set on the longitudinal strip which divides the two sides of the rack. These are labelled to designate the genus, or in case a large number of containers is used for one species, the species name may be shown on these guides. For very large specimens we find it unnecessary to employ the double tube system. The accompanying illustration shows a rack partially filled with containers. Note the cardboard riders which are used as guides and the label on the end of the rack.

A number of advantages have been found in this method. It saves space by having the material more concentrated than where collections are preserved in individual vials; these large containers do not dry out so rapidly as small ones; there is not the usual trouble with the corks becoming hard and loose, owing to direct contact with the alcohol, and the specimens will remain moist as long as there is the smallest trace of alcohol in the container; the collection presents a neatness and uniformity which adds to its appearance and aids in classification and ease of finding material; the large size of the containers permits of having a label stuck to each, thus avoiding tag labels tied on small vials or loss of time necessary to look at the labels within hundreds of alcoholic vials; there is a large saving by not having to go through a great number of small vials in filling them, as each container will hold from one to fourteen of the individual vials. Furthermore, it is possible to allow an untrained helper to fill the containers as the material itself is never touched and there is no danger of losing specimens by overflowing individual vials.

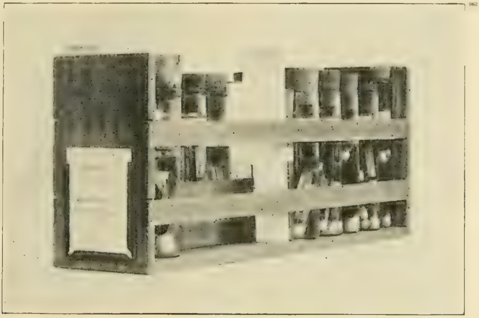

Figure 1

Of course the kinds of racks in which the material is kept and the system of filing them should depend upon the individual needs and conditions, but the essential system, that of having a large outside container with a number of individual vials therein, may be employed in almost any museum or laboratory.

At Dallas it has been the practice to accession all material before it is put away, each lot receiving an accession number. The labels are made as brief as possible, usually only the name of the species and accession number being given. When it is desired to get more complete data the accession catalogue (in card form) may be consulted. Our labels are made with India ink. They are thoroughly dried by heat before using. We have found it possible to save time in the future by writing the accession number on both sides of each label. The method of labelling, of course, is also subject to change according to individual preference. As far as possible, the vials containing material of a given species are placed in the containers in numerical sequence. When time permits they may be arranged in perfect numerical order, and the number of the container (the series containing each species to begin with No. 1) as well as the inclusive accession numbers of the material in each inserted on the container label.

For convenience sake we have found it advisable to divide the entire alcoholic series into three parts, numbering these series I, II and III. Series I contains all the material under the accession catalogue which it is desired to keep; series II (the "life history series") contains bred material which is designed to illustrate all of the different stages of an insect or other form; series III is composed of specimens for exchange, or in other words a duplicate series.

I have recently observed a number of different systems for arranging alcoholic material in different laboratories and museums, and have heard several say they did not like the double-tube system. In these cases, however, the containers used were very little larger than the vials containing the specimens, therefore each container was occupied by but a single vial of specimens. This only tends to increase the volume of the collection, does not facilitate refilling with alcohol, and the containers do not hold enough alcohol to prevent frequent fillings. I am of the opinion that if the double-container system, as described above, is employed, it will be found to be very free from objectionable points.

NOTES ON THE BIOLOGY OF PARAPHELINUS SPECIOSISSIMUS GIRAULT.

By W. R. McConnell,

Scientific Assistant, U. S. Department of Agriculture, Bureau of Entomology, Cereal and Forage Insect Investigations.

It is well known that the Chalcidoids of the Tribe *Aphelinini* are among the most important parasites of Scale Insects, particularly of the *Diaspinæ*, and that they also parasitize *Aphididæ* and *Aleyrodidæ*. The only exceptions appear to belong to the genus *Paraphelinus*, erected by Perkins in 1906 (Bull. 1, part 8, Report of Work of the Experiment Station of the Hawaiian Sugar Planter's Association, 1906, p. 264) to contain his *P. xiphidii*. In describing the species *P. tomaspinis*, Dr. Howard has given a compact summary of the facts known regarding the biology of this genus (Proc. Ent. Soc. Wash., XVI, 1914, pp. 81–82), which is as follows:

"Perkins's *P. xiphidii* was reared from the eggs of *Xiphidium varipenne* Swezey. The only other species so far discovered, viz.: *P. speciosissimus* Girault (Journ. N. Y. Ent. Soc., 1911, p. 181) and *P. australiensis* Girault (Archiv fur Naturgeschichte, 1913, pp. 74–75, Ab. A. 6 heft), were both described from single captured specimens, so that their host relations are unknown. The receipt of the new species here described from Mr. P. L. Guppy, of Trinidad, who reared it from the eggs of the sugar cane leaf-hopper, *Tomaspis varia*, makes it probable that all species of this interesting genus are parasites in the eggs of Orthoptera and Homoptera that are inserted in twigs or canes. This would be an unique feature in *Aphelinine* biology (the other forms all ovipositing only in Coccidæ, Aphididæ and Aleyrodidæ) were it not for the old disputed species *Agonioneurus locustarum* Giraud (placed in *Aphelinus* by Dalla Torre) and which was described by Dr. J. Giraud in his Memoir on the insects which live upon the common rose (Verh. d. Zool.-Bot. ges. Wien., Vol. 18, 1863, pp. 1278–1279) and which he reared from the eggs of *Xiphidium fuscum* F. It seems to me quite possible that in the old *A. locustarum* we may have another species of *Paraphelinus*. There is nothing in the original description which would seriously deny this guess, except the absence of the hairless discal streak on the primaries, and this is obscure in the species about to be described."

We were quite surprised to find last July that an *Aphelinine* was emerging from Hessian Fly puparia. These have been determined by Mr. A. B. Gahan, of the Bureau of Entomology, as *Paraphelinus speciosissimus* Girault. As will be noted from the above quotation, it requires only a slight elaboration of Dr. Howard's theory to include as a host for this genus the Hessian Fly, whose puparia resemble superficially the eggs of an Orthopterous insect and are embedded in the stems of wheat.

The original specimens upon which the present data are based were secured from wheat stubbles collected by Mr. P. R. Myers of the Bureau of Entomology. The puparia were removed from these stubbles and placed in cages containing nothing else. Adults reared from these puparia were used by the writer in experimentally parasitizing other puparia known to be absolutely free from any parasites, and three more successive generations have thus been reared from the original parents, The rearing has been conducted at Hagerstown, Md., and all data here given apply to laboratory conditions at that point.

DISTRIBUTION.

Girault's original specimen was collected on a granary window at Urbana, Ill. In spite of the fact that we have reared large numbers of Hessian Fly puparia from various points in Pennsylvania, Maryland, Virginia and West Virginia, we have thus far secured this parasite only from the following six localities in central Pennsylvania: Linden, Montoursville, Muncy, Montgomery, Northumberland, and Andersonburg. The first five localities are in two adjoining counties along the Susquehanna River, where a serious outbreak of Hessian Fly occurred. The last locality is about fifty miles southwest from Northumberland, and here only about 31% of the stubbles were infested by the Hessian Fly. Out of a total of 3165 puparia secured from all of these localities, only 17, or a little more than .005%, were parasitized by this Chalcidoid. Some fields in each locality yielded none of these parasites, while in the other fields the percentage of parasitization varied from 0.14% at Andersonburg to 3.2% in one field at Muncy. In the latter field Mr. Myers estimated that 65% of the stubbles were fly-infested.

ADULT.

The adults are beautiful little insects with head and abdomen almost entirely black, thorax and legs chiefly light yellow, a dark band across the front wings and ovipositor exserted. The females average about 0.8 mm. long; the males, about 0.5 mm.

This species is a primary multiple parasite of the Hessian Fly. It has been demonstrated repeatedly that it is a primary parasite, not only by rearing it from the Hessian Fly, but by experimentally parasitizing Hessian Fly puparia known to be free from parasites. It would seem to promise much as a primary parasite of this host because several adults usually emerge from a single host. This is not due to polyembryony but to multiple egg deposition, as shown by the recovery by dissection of eggs deposited in puparia. The number of adults emerging from a puparium varies from 1–10, with an average of about 7, for puparia experimentally parasitized. This average is considerably lower under field conditions as they obtained last year. Eleven eggs have been dissected from one host parasitized in the laboratory, and another contained twenty-one living larvæ, two dead larvæ and two dead eggs. In this case the evident excessive parasitization had already begun to right itself.

The adults emerge through a round hole in the middle region of the puparium, and usually there is a single one. Sometimes two exit holes are cut, and occasionally three. When there is a single exit hole it is frequently much larger than would seem necessary. The exit holes vary in size from 0.2 mm. to 0.45 mm. with an average for ten puparia of 0.33 mm., while according to measurements made by Mr. Myers the largest diameter of the thorax averaged 0.24 mm. for the females, while in the males it is only 0.18 mm.

All adults usually emerge from a puparium about the same time, but occasionally they may emerge throughout the day, and in one case the last female emerged two days later than the others. In many cases both sexes emerge from the same puparium. In laboratory cages where both sexes were introduced, about 18% of the progeny were males. In one cage into which only unfertilized females were placed, all of the progeny were males. It is apparent from this that the species is arrhenotokous, but there has been no opportunity for carrying parthenogenesis through several successive generations.

When there is opportunity, mating occurs shortly after emergence, and there is little doubt that one male is capable of fertilizing several females. Oviposition may begin very shortly after emergence. In fact, it is difficult to remove females from cages and make sure that they have not oviposited in other puparia in the same cage. The females continue oviposition for several days. In cages, adults usually do not live longer than three to six days, but if they do not oviposit their life may be much longer. In one cage they have lived seventeen days. They feed on sugar solution, but have not been observed feeding at punctures in the host made by the ovipositor.

The females will oviposit in purparia concealed in young wheat plants and in dry dead stubbles as well as in uncovered puparia. It seems to make no difference whether the puparium contains a larval or a pupal host, as both stages are successfully parasitized.

EGG.

The eggs of this parasite are deposited in the body cavity of the host. Ten eggs averaged 0.166 mm. in length by 0.057 mm. in greatest width. They are white and translucent and the chorion is devoid of sculpture. The eggs are ovate and stalked, the stalk being about one-third the length of the egg proper. The stalk is attached excentrically at one end of the egg, slightly curved toward its main axis, and is wide at the base tapering rapidly to a rather bluntly rounded apex.

LARVA.

Nearly grown larvæ are yellowish white with the exception of the light brown mandibles. The head is about twice as wide as long and bears at each antero-lateral region a large conical process directed forward. These lateral projections are peculiarly striking and may be simply a means of exposing more surface to the fluids of the host. The front between these processes is almost straight, but there is a decided concavity ventrally between the lateral processes. The mandibles are simple, conical, sharply pointed, slightly curved, and the tips slightly overlap. The mouth opens just below them. The body apparently consists of thirteen segments. These are distinct in the anterior region but posteriorly are difficult to distinguish.

There is a pair of short tubercles on the ventral region of the prothorax and these are evidently vestigial prothoracic legs. No spiracles have been observed, but they probably do not open up until just before pupation. The body is devoid of hairs. The alimentary canal is a large sac closed behind and filled with yellowish material. There is a posterior anal notch but the proctodæum apparently lacks a lumen. A pair of salivary glands may be seen starting back from a common duct originating ventral to the mouth cavity. While alive the larvæ exhibit a rhythmic opening and closing of the mouth, but the mandibles are not moved while this is in progress, and periodic swallowing movements occur.

In full grown larvæ the body is somewhat shorter and broader and the processes on the head slightly less conspicuous. Larvæ at this stage are about 1 mm. long and 0.3 mm. wide.

Pupation takes place inside the skin of the host. The latter is rounded out into a more or less elliptical cell and becomes dry and light brown in color. The larvæ have a strong tendency to arrange themselves before pupation with their heads diercted toward the center of this cell, and in this cell just prior to pupation they void their excrement, which consists of numerous dark reddish brown disks.

PUPA.

The pupa when first formed, is white with an elongate orange spot, showing through the middle of the dorsum of the abdomen. The average of four pupæ gave a length of 1.063 mm. by 0.356 mm.

LIFE HISTORY.

Accurate data for the length of the various stages of this parasite have not been secured. However, in one cage where the adults began to oviposit in host puparia on July 29th, larvæ almost full-grown in hosts almost entirely consumed were dissected out on August 3d, after a period of only five days. This shows that at this season development is very rapid and that the egg and larval stages are very short. In another cage numerous pupæ and no larvæ were dissected August 4th from host puparia into which parasites began to oviposit July 24th. Adults emerged from these pupæ August 13th and 14th, showing that the pupa stage required at least nine days. From these and other cages it was found that complete development from oviposition to emergence required from eighteen to twenty days at this season of the year. Developmental processes slow up with the approach of cold weather. We do not know the number of generations per year, but beginning July 24th, we ran one cage in which three generations matured by October 19th, the first beginning to appear August 20th, the second September 14th and the third on the date mentioned. Assuming that the parent generation required twenty days, there could be four generations from July 4th up to the last of October. Under field conditions at the points where the original specimens were collected, this last generation might not be produced.

In any event, there is time enough in one season for an enormous multiplication of this parasite. Puparia collected shortly before emergence of the host would probably show a much higher percentage of parasitism than that shown by our figures. Consequently, *Paraphelinus speciosissimus* may prove in the future to be an important agent in the control of a serious outbreak of the Hessian Fly and the fact that one host may serve to develop as many as ten adults would indicate that it could maintain its numbers at a relatively high level during seasons when the host is scarce.

ADDITIONAL NOTES ON THE GENUS PTEROCOMMA.

By H. F. Wilson.

The writer has published in the December, 1915, issue of the Annals, a paper under title, "A Synopsis of the Aphid Tribe *Pterocommini*." Mr. J. J. Davis has called to my attention two citations not listed in my paper, both of which include descriptions of new species.

The first paper the writer does not have, but it was published by Alexander Mordwilko in 1901, in Vol. 33, Horæ Society of Entomology of Russia. A new species is described as *Cladobius steinheili.*

Mr. Davis has loaned me one slide containing five specimens, only one of which seems to be mature. The specimens are similar to *Pterocomma bicolor* Oestlund, but may be a distinct species. There were not a sufficient number of specimens present to determine the species accurately.

The second paper was by Miss Edith Patch in Bull. 213 of the Maine Experiment Station in which Miss Patch describes a species as new under the name of *Melanoxantherium antennatum.* This species is distinctly different from all of the other members of this group in generic characters and does not belong in the genus *Pterocomma* nor in the tribe *Pterocommini.*

Mr. Davis also suggests that *Cladobius rufulus* Davidson is a synonym of *Pterocomma bicolor* Oestlund rather than *P. populeus* Linn. In this connection, I may say that these two species or almost identically similar ones are found along the Pacific Coast and they have both been confused under the name of *rufulus.* Mr. Davidson also seems to have confused them and the slides sent to me by him seemed nearer to *populeus* than to *bicolor.* *Pterocomma bicolor* covers an extremely wide distribution and shows great variation in the size and shape of the nectaries.

FRANCES MARION WEBSTER.

AN APPRECIATION.

The Entomological Society of America has in the death of its honored President lost not only its chief officer but one of its most loyal members and supporters throughout its entire career.

It seemed therefore especially fitting that it should give expression to its sorrow and an appreciation of its profound regard for Professor Webster without waiting for the usual formal resolutions adopted by the Society at its annual meeting in recognition of its honored dead.

With hearty accord of officers and editorial board the writer undertakes to express the appreciation which we believe must be felt by every member of the Society.

Professor Webster has been a long time and trusted friend and the writer feels a sense of personal loss far beyond expression in the usual phrases. A personal acquaintance and friendship of more than a quarter century has suddenly ceased but the memory of that friendship and the influence of his enthusiasm and the spirit of his fine ideals are possessions to be held for life.

Professor Webster built himself into the structure of American Entomology by persistence and force of character and in face of difficulties which would have discouraged any man of less determination. His work was varied and embraced a wide range of Entomological Science; all was sincere and honest and much of it will endure as of permanent value to mankind. He brought to each task the energy of purpose and the foundation of fruitful experience. The loyalty of his friends and assistants testify to the sincerity and wisdom of his efforts.

J. M. Webster

I saw him last on Sunday a few hours before his death and in spite of his desperate condition he showed the force and the cheerful hopefulness characteristic of the man. He said that he realized it was perhaps unwise for him to make the trip to Columbus but that he was especially anxious to meet his Entomological friends and expressed his pleasure in the meeting and keen regret that two of his oldest friends among the Entomologists whom he had hoped to meet had not been present. I feel that I may fairly convey to them and all his host of friends the farewell greeting of a fallen comrade.

He was keenly appreciative of the honor of his election to the Presidency and it seems especially fitting that this tribute of his co-workers should have been conferred in time for him to have the pleasure it might afford him.

Prof. Webster was born in Lebanon, N. H., August 8th, 1849, and died in Columbus, Ohio, January 3d, 1916. As Assistant to the State Entomologist of Illinois; Agent of the U. S. Division of Entomology in the Department of Agriculture; Entomologist of the Ohio Experiment Station; and lastly, Chief of the Division of Cereal and Forage Crop Insects in the Bureau of Entomology he stepped from one important duty to another and in his last position doubtless wielded his greatest influence upon the growth of Economic Entomology.

Practically his whole life has been devoted to his favorite study and he died, as doubtless he would have wished, while in active participation of duties connected with his life work. American Entomology has lost a leader but will hold and treasure an example of devotion and fruitful effort.

HERBERT OSBORN.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

Columbus Meeting.

The first meeting of the Tenth Annual Meeting of the Entomological Society of America was held in Botany and Zoology Hall of the Ohio State University, on Wednesday, December 28, and was called to order by President Vernon L. Kellogg at 2:00 P. M. The following papers were presented:

D. M. DeLong, Ohio State University—Notes on the Jassoidea of Tennessee.

N. E. McIndoo, U. S. Bureau of Entomology—The Olfactory-Gustatory Sense of the Honey Bee. Read by title.

William Moore, University of Minnesota—How Gases enter Insects.

A Franklin Shull, University of Michigan—Parthenogenesis and Sex in *Anthothrips verbasci*. Read by title.

Eric S. Cogan, Ohio State University—The Homopterous Mouth.

H. C. Severin, South Dakota State College of Agriculture—The Life-History, Economic Importance, and Control of the Carpenter Moth in South Dakota. Read by title.

F. E. Chidester, New Jersey Agricultural Experiment Station—The Influence of Salinity upon the Development of the Salt Marsh Mosquito. Read by title.

W. R. McConnell, U. S. Bureau of Entomology—Notes on the Biology of *Paraphelinus speciosissimus* Girault. Read by title.

C. H. Richardson, New Jersey Experiment Station—The Attraction of Diptera to Ammonia. Presented by Thomas J. Headlee.

The President was directed by motion to appoint the following committees on organization and named the following:

Committee on Resolutions—J. M. Aldrich, Paul S. Welch and Edith M. Patch.

Committee on Nominations—F. M. Webster, T. J. Headlee and William Moore.

Auditing Committee—William A. Riley, Eric S. Cogan and C. L. Metcalf.

The Society then adjourned for the afternoon.

The meeting for the Annual Public Address was held in the banqueting room of the Southern Hotel and was called to order at 8:00 P. M. by President Kellogg. The speaker of the evening was Dr. C. Gordon Hewitt, Dominion Entomologist, who gave "A Review of Applied Entomology in the British Empire." The meeting was well attended and the visiting entomologists were entertained after the address by the Entomologists of Ohio at a smoker and burlesque, which all agreed in pronouncing a great success.

The Society convened on Thursday, December 30, at 10:00 A. M. in a joint session with the American Association of Economic Entomologists, with President Vernon L. Kellogg in the chair, for the presentation of the two following papers:

L. O. HOWARD, Chief U. S. Bureau of Entomology—An Appreciation of the Hawaiian Parasite Introduction Work.

F. M. WEBSTER, U. S. Bureau of Entomology—Ethnoentomology. Presented by E. P. Felt, because of the illness of Mr. Webster.

The joint session was adjourned and the following paper was read:

J. L. KING, University of Illinois—The Life-history of *Pterodontia.*

The Society then adjourned until 2:00 P. M.

The Secretary upon the reconvening of the Society, presented the following report for the Executive Committee:

REPORT OF THE EXECUTIVE COMMITTEE.

The annual meeting of the Executive Committee was held in the office of Professor Herbert Osborn, at the Ohio State University, Wednesday, December 29th, with the following members present: James S. Hine, J. M. Aldrich, Herbert Osborn, W. A. Riley and A. D. MacGillivray.

The most important matter considered by the Executive Committee in the interim since the last Annual Meeting was the selection and appointment of Dr. C. Gordon Hewitt to give the Annual Public Address at the Columbus meeting.

The following new members were elected by the Executive Committee June 1st, 1915:

F. W. Dry
G. A. Chandler
F. A. Fenton
C. M. Packard
N. K. Jardine
O. S. Wescott
R. L. Nougaret
Howard Curran

The following members have died during the past year:

Donaldson Bodine
Roe Niver
E. E. Phillips
Andrew Rutherford

The following resignations were presented and accepted:

Newton L. Partridge
E. Dwight Sanderson
Charles Piper Smith
Howard E. Weed

The following were elected to membership by the Executive Committee at its meeting on Wednesday:

R. A. Muttkowski
J. S. Wade
H. H. Jewett
J. S. Rogers
S. L. Alexander
D. G. Tower
George Newman
L. O. Jackson
J. K. Thibault
C. F. Stiles
E. K. Parker
E. B. Powers
H. V. Heimburger
F. Silvestri
R. T. Cotton
F. H. Benjamin
C. F. W. Muesebeck
J. L. Hypes
L. B. Ripley
J. M. Robinson
F. O. Coe
P. A. Munz
F. L. Thomas
G. H. Vansell
B. P. Young
F. G. Carnochan
J. W. Chapman

The following report of receipts and expenditures was submitted by the Treasurer:

RECEIPTS.

Trust Funds:		
Life Membership Fees deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1914	$150.00	
Life Membership Fee of Seth Bunker Capp deposited with Cleveland Trust Company, Cleveland, O., Feb. 4, 1915	50.00	
Samuel Hubbard Scudder Fund deposited with Cleveland Trust Company, Cleveland, Ohio, May 18, 1915	35.00	
		$235.00
Cash:		
Cash on deposit in the First National Bank of Champaign, Illinois, December 14, 1914	$136.46	
Cash received from Herbert Osborn, Managing Editor of the ANNALS	262.14	
Cash collected as dues	693.69	
Interest on Fees of Life Members, Scudder Fund, and interest compounded from May 3, 1912 to July 1, 1915	17.19	
		1,109.48
		$1,344.48

BALANCE.

Bills Paid, ANNALS:		
Annals and Separates, September, 1914	192.20	
Annals and Separates, December, 1914	235.80	
Annals and Separates, March, 1915	270.00	
Annals, Engraving	90.20	
		$814.56
Bills Paid, Secretary-Treasurer's Office:		
Stamps and Stamped Envelopes	$47.42	
Printing and Supplies	60.18	
Stenographer and Office Help	38.85	
Writing Certificates for 1914	11.80	
		158.25
Thomas Say Foundation, printing		9.12
Life Membership Fees deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		200.00
Samuel Hubbard Scudder Fund deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		35.00
Interest on Fees of Life Members, interest compounded, and Samuel Hubbard Scudder Fund, deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		17.19
Cash on deposit in the First National Bank of Champaign, Illinois, December 27, 1915		110.36
		$1,344.48

The names of the following Fellows were recommended to the Executive Committee for election as Honorary Fellows:

Stephen Alfred Forbes
Samuel Wendall Williston.

These recommendations were adopted by the Executive Committee and in accordance with the Constitution, were referred to the Fellows for a mail ballot. This ballot was taken during the past year, and the Executive Committee now declares them duly elected.

The following report was submitted by the Managing Editor of the Annals of the Entomological Society of America:

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

The volume for the year 1915 has been kept within four hundred pages, as the income for the year did not seem to warrant further expansion. We have had but few orders from outside the United States and fewer sets of volumes have been placed this year than last.

The total receipts for the office have been $323.41:

Subscription account	$222.55
Sale of back numbers	53.71
Sale of reprints	47.15

The expenses for various items have been $61.27:

Stamps, express, and post office charges	$29.98
Stenographic help and office supplies	20.54
Engraving	10.75

Amount turned over to the Treasurer $262.14.

It may be mentioned that the prospective income for the coming year will insure a fair volume and the maintainance of the Annals at its present standing may be considered as practically assured.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

The following, J. H. Emerton, C. Gordon Hewitt and Lawrence Bruner, were elected as members of the Editorial Board of the Annals for three years. The terms of J. H. Comstock, C. J. S. Bethune and C. W. Johnson having expired.

The Secretary was directed by the Executive Committee at the Washington meeting to sell the collection of books and papers presented to the Society by Samuel Hubard Scudder at the time he was elected an Honorary Fellow. Their sale was accomplished during the present year for the sum of thirty-five dollars and this sum was deposited with the Cleveland Trust Company, as directed by the Executive Committee, as already stated in the report of the Treasurer. The Executive Committee moved that fifteen dollars of the interest that has accrued to date be transferred to this fund, making it a fund of fifty dollars, which was to be known as the Samuel Hubbard Scudder Fund.

The Secretary presented for the Temporary Committee of the Thomas Say Foundation appointed at the Philadelphia meeting, the following report:

REPORT OF THE THOMAS SAY FOUNDATION.

The Temporary Committee of the Thomas Say Foundation, by special permission of the Executive Committee of the Entomological Society of America, sent to each member of the Society with the call that was issued for the San Francisco meeting, the following letter:

May 15th, 1915.

Members of the Entomological Society of America:

The Entomological Society of America at its Philadelphia meeting established the Thomas Say Foundation for the publication of works dealing with American insects. These works to be limited to those of a monographic or bibliographic character and to be of such size as to make a separate volume of one hundred or more pages. The persons named at the head of this sheet were appointed a temporary committee with power to solicit funds, to choose works for publication, to determine the form of the publication, and to print such volumes for which the committee has funds and which it considers worthy of publication.

The committee on publication must have funds before the publication of such a series of volumes can be inaugurated. With the consent of the Executive Committee of the Entomological Society of America, the committee of the Thomas Say Foundation are sending the following appeal and proposition to the members of the Society.

It is agreed that those persons who will make a preliminary subscription of ten dollars ($10.00) towards the Thomas Say Foundation are to be considered charter subscribers and are to receive such volumes as the Foundation may issue, equivalent to the amount of their subscription. The Executive Committee of the Entomological Society of America also authorizes the publication committee of the Thomas Say Foundation to guarantee to those persons making a subscription of ten dollars, that in case no volumes of the Thomas Say Foundation are issued, that they shall be freed from the payment of all annual dues to the Entomological Society of America for a period of five years or for an amount equivalent to their subscription.

It is hoped that all those persons who are interested in the development of such a series of monographs and catalogues of American insects as is contemplated in the Thomas Say Foundation will aid the Committee.

Respectfully submitted,

MORGAN HEBARD, *Treasurer.*
ALEX. D. MACGILLIVRAY, *Editor.*

SUBSCRIPTION.

I send herewith the sum of ten dollars ($10.00) to Morgan Hebard, Treasurer of the Thomas Say Foundation as a preliminary subscription to the said Foundation with the understanding that I am to be considered a charter subscriber, that I am to receive such volumes of the Foundation as are issued equivalent to the amount of my subscription, and that in case no volumes are issued the Entomological Society of America is to credit me with the payment of my dues to the Society for a period of five years.

Name..

Street..

Town.. *State*...

The following report was received from the Treasurer of the Foundation:

I regret that I will be unable to attend the Columbus meeting and would therefore like to submit to you the report of the Thomas Say

Foundation. The receipts to date total $170.00 and no expenses as yet have been incurred. The following are subscribers:

William Barnes
P. P. Calvert
T. D. A. Cockerell
William T. Davis
G. P. Englehardt
M. Hebard
S. Henshaw
A. D. MacGillivray
William S. Marshall
Isabel McCracken
A. L. Melander
Herbert Osborn
William A. Riley
Mrs. A. T. Slosson
P. H. Timberlake
E. B. Williamson
Entomological Branch, Dept. Agr., Ottawa, Ont.

It would seem wholly ill-advised to use any of this money at present. I think that by again sending out appeals we could possibly increase the amount quite considerably. In the meantime, every effort should be used to bring this Foundation before the notice of those who are able and might be willing to establish a reasonably large endowment. Until sufficient funds are available to insure at least some annual income, no publication could well be undertaken with any prospect of continued activity. If any suggestions can be made for the furtherance of this work, I will be glad to co-operate to the best of my ability. The funds are deposited in the name of the Foundation with the Girard Trust Company, of Philadelphia. This institution does not allow interest on deposits of less than $500.

MORGAN HEBARD, *Treasurer.*

The report of the committee on ways and means, its adoption by the Executive Committee of the Entomological Society of America, their appointment of a temporary committee of five, and the election of a treasurer and an editor by this temporary committee, has already been detailed in the proceedings of the Philadelphia meeting of this Society.

Several methods appear to be possible in financing the projected publication. An endowment sufficiently large to provide constant income for printing would be ideal. Almost equally satisfactory would be a working capital of about twenty thousand dollars, which would return in the sale of the publications so that it could be used indefinitely. Special appeal to one of the large scientific foundations might secure the printing of some work of especial timeliness and value. And last, but not least important, subscriptions from members might enable a beginning to be made.

The subscription method offers the most available means for the early issuance of a volume and while a fund of some size is not essential for the carrying out of this method, yet it would be necessary for the members of the committee individually or collectively or some friend of the committee to be financially responsible for the composition, printing, and binding of the first volume until sufficient funds had been accumulated for its sale to recompense the printer. This method has been used successfully by some of the European societies, notably the Ray Society of England, which was founded in 1844, and has issued two or three volumes each year. Although the Ray Society has been publishing volumes for seventy years, yet so far as can be judged from its financial reports, which were issued annually in one of its volumes, it has never had an endowment fund, but has depended entirely upon annual subscriptions to meet the expense of publication. Whether the number of entomologists, schools, libraries, experiment stations and universities, that would be willing to subscribe for such volumes as might be issued by the Thomas Say Foundation would be large enough to meet the expenses of publication has not been determined by the temporary committee.

There has been expended of the fifty dollars set aside by the Executive Committee at the Philadelphia meeting for the use of the temporary committee of the Thomas Say Foundation, the sum of nine dollars and twelve cents for the printing of letter heads, the letter above described, and envelopes. The permission to include this letter with the call for the San Francisco meeting did not increase the amount of postage per letter for the Entomological Society of America, so that there has been no expense to the Society other than the printing named above.

Respectfully submitted for the temporary committee,

ALEX. D. MACGILLIVRAY.

The Executive Committee named the following temporary committee to look after the Thomas Say Foundation for the year 1916: J. M. Aldrich, Nathan Banks, A. D. MacGillivray, E. B. Williamson, Morgan Hebard, Treasurer, and Philip P. Calvert, Editor.

On motion the report of the Executive Committee was adopted.

REPORT OF COMMITTEE ON NOMINATIONS.

The undersigned, your committee on nominations, giving the matter as careful consideration as time would permit, desire to present the following names for your consideration:

First Vice-President: E. P. Felt, New York State Entomologist, Albany, N. Y.

Second Vice-President: A. L. Melander, Washington Agricultural College, Pullman, Washington.

Secretary-Treasurer: J. M. Aldrich, U. S. Bureau of Entomology, West Lafayette, Indiana.

Additional Members of the Executive Committee:

H. T. Fernald, Massachusetts Agricultural College, Amherst, Massachusetts.

W. E. Britton, Connecticut Agricultural Experiment Station, New Haven, Connecticut.

P. J. Parrott, New York Agricultural Experiment Station, Geneva, New York.

E. D. Ball, Dean Utah Agricultural Experiment Station, Logan, Utah.

C. Gordon Hewitt, Dominion Entomologist, Ottawa, Canada.

On the question of the nomination of President, the committee became divided, two of the members of committee felt that the proper person for this position was the chairman of the committee, Mr. F. M. Webster, U. S. Bureau of Entomology, Washington, D. C., and the majority vote of the committee decided to recommend Mr. F. M. Webster for our next President.

Member of Committee on Nomenclature:

E. P. Felt, New York State Entomologist, Albany, N. Y.

(Signed) THOMAS J. HEADLEE,
WILLIAM MOORE.

On motion, the Secretary was instructed to cast a ballot for the officers named and they were declared elected.

COMMITTEE ON RESOLUTIONS.

Your Committee on Resolutions beg leave to report as follows:

Our meeting at the Ohio State University has been rendered unusually pleasant by the hospitality of the entire staff of the institution, and especially by the kindness and careful attentiveness of the members of the Department of Zoology and Entomology, to all of whom our thanks are due.

We congratulate Professor Herbert Osborn on the fine and servicable building in which his work is now carried on, and desire to express our continued obligation to him for his services as Managing Editor of the Annals.

The retirement of Professor MacGillivray from the post of Secretary-Treasurer should not pass without acknowledgment of his efficient service; he has performed the numerous duties of his office with rare fidelity and good judgment, and the present standing of our Society is in considerable measure due to this fact.

Respectfully submitted,

J. M. ALDRICH,
PAUL S. WELCH,
EDITH M. PATCH.

On motion, the report was adopted.

REPORT OF THE AUDITING COMMITTEE.

COLUMBUS, OHIO, Dec. 30, 1915.

We, the undersigned, have this day examined the accounts of Alexander D. MacGillivray, Treasurer and Secretary of the Entomological Society of America, for the year ending December 27th, 1915, and the accounts of Herbert Osborn, Managing Editor of the Annals of the Entomological Society of America for the year ending December 1st, 1915, compared the vouchers therewith and found them correct and properly cast.

(Signed) WILLIAM A. RILEY,
ERIC S. COGAN
C. L. METCALF.

On motion, the report was adopted.

REPORT OF THE COMMITTEE ON NOMENCLATURE.

Pursuant to instructions given at the last Annual Meeting, two members of the Committee on Nomenclature suggest the following rule in relation to designations of supergeneric value. Tribe, subfamily, family, and superfamily names should be formed by adding the endings *ini*, *inae*, *idae*, and *oidea*, respectfully to the root of an included, persumably typical and valid genus.

The Committee has not been able to prepare the desired list of the more important names in each order which are in danger of being lost or changed in sense by a strict application of the rules of nomenclature, and it takes this opportunity of inviting specialists in the various groups to submit a list of names with recommendations as to the same.

Respectfully submitted,

E. P. Felt,
T. D. A. Cockerell,
Members of the Committee in Agreement.

The other member of the Committee, Mr. Nathan Banks, is opposed to piece-meal efforts along nomenclatorial lines and to any exceptions to the law of priority and has stated that he does not care to serve upon the Committee.

On motion the report of the Committee on Nomenclature was adopted.

The following amendment to the Constitution of the Entomological Society of America submitted at the Philadelphia meeting, was read and the following substitution for Section 1, as printed in the proceedings of the Philadelphia meeting, is offered by the Executive Committee of this meeting, so that the amendment as a whole, to constitute Article VIII of the Constitution is as follows:

ARTICLE VIII.

Section 1. *Name*—There is hereby established a standing committee of the Society under the name of "The Thomas Say Foundation."

Sec. 2. *Purpose*—The purpose of this Foundation is for the publication of works of a monographic or bibliographic character on the insects of North America.

Sec. 3. *Publication*—Each publication shall be a volume complete in itself, and numbered consecutively.

Sec. 4. *Committee*—This committee shall consist of six members, four of them to be elected by the Executive Committee of the Society, two of them retiring annually, and an Editor and a Treasurer, to be designated by the Executive Committee.

Sec. 5. *Powers*—This Committee is empowered to determine all matters concerning the publication.

Sec. 6. *Funds*—They are also empowered to solicit, hold, invest, and expend funds committed to their care; only the interest of any endowment to be available.

Sec. 7. *Responsibility*—The Society shall be in no way responsible for debts contracted by this Foundation, unless previously authorized by the Executive Committee.

Sec. 8. *Reports*—The Editor and Treasurer shall present a report of their operations and expenditures to the Executive Committee at each Annual Meeting, and the accounts of the Treasurer shall be audited by the Auditing Committee of the Society. These reports shall be published as a part of the proceedings of the Executive Committee of each Annual Meeting.

On motion, the amendment as above stated, was adopted.

Objections were raised to the time of scheduling the meetings of the Entomological Society of America during Convocation Week. The earlier meetings of the Society were held during the first days of the week, but at the Philadelphia meeting were changed to the last two days of the week and during this meeting were held on Wednesday and Thursday. The plan of holding the meetings at the end of the week was severely criticized by some members as well as the arrangement at this meeting, although both arrangements were at the request of certain members. It seemed to be the unanimous opinion of all members present at the Columbus meeting that the meetings of the Entomological Society of America and of the American Association of Economic Entomologists should not be in session at the same time, because the membership of the two societies are practically identical and the members desire to attend all the meetings of both societies. The following motion was offered and carried:

Resolved, that it is the wish of the members of this Society that its annual meeting for the reading of papers be held, as formerly, at the beginning of Convocation Week, and that the Secretary is requested to confer with the Secretary of the American Association of Economic Entomologists to see if this can not be arranged.

The following papers were then presented:

C. L. Metcalf, Ohio State University—Metamorphosis of the Syrphidæ.

Alvah Peterson, University of Illinois—The Epipharynx and Hypopharynx of the Diptera.

W. E. Britton, Connecticut Agricultural Experiment Station—Notes on Certain European and Other Foreign Insects Occurring in Connecticut. Read by title.

Philip Garman, University of Illinois—Specific and Individual Variation in the Gills of the Nymphs of the Zygoptera.

V. E. Shelford, University of Illinois—An Analysis of the Color-Patterns of Cicindela.

C. C. Hamilton, University of Illinois—Notes on a Twig-Dwelling Cicindelid.

S. B. Fracker, Assistant State Entomologist of Wisconsin—The Immature Stages of *Schroeckensteinia*, a New Raspberry Pest.

Paul S. Welch, Kansas Agricultural College—Contribution to the Biology of Certain Aquatic Lepidoptera. Read by title.

A. C. Burrill, University of Wisconsin—House-Ant Trails and their Bearings on Economic Control. Presented by S. B. Fracker.

Frederick Knab, U. S. National Museum—The Dispersal of Diptera beyond their Natural Habitat. Read by title.

The exhibition was held in the Zoology and Botany building under the direction of Professor James S. Hine. The following exhibits were shown:

J. H. Emerton, Boston, Massachusetts—Circulating Collection of Spiders.

Edith M. Patch, Maine Agricultural Experiment Station—Host Plant Outlines of a few Aphids Based upon Original Observations in Maine.

E. W. Berger, Entomologist of Florida State Plant Board—Fungus Parasites of Scale-Insects and White-Flies in Florida.

Don C. Mote, Ohio Agricultural Experiment Station—Warble-Fly Injury.

J. R. Watson, Florida Agricultural Experiment Station—Life-History of *Anticarsia gemmatilis*.

R. W. Coleman and W. A. Riley, Cornell University—Wax Model of Repugnatorial Glands and their Muscles in *Anasa* nymph.

On motion, the Society adjourned to meet in one year with the American Association for the Advancement of Science at New York, N. Y.

Alex. D. MacGillivray, *Secretary*.

NOTICE TO MEMBERS AND CONTRIBUTORS.

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5x7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

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ANNALS

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Volume IX JUNE, 1916 Number 2

BREEDING HABITS OF THE ORTHOPTERA.

Clarence L. Turner.

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INTRODUCTION.*

The Orthoptera are the most primitive insects according to Palæontological evidence. During the early Carboniferous period the insect fauna was composed entirely of the ancestors of this group, and during the latter part of the period the members of this stock far outnumbered that of any other order of insects. Fossil evidence proves that many of the primitive types are represented at the present by species that, in spite of the long intervening periods, have changed but little. New types have arisen, however, until the Orthoptera as they are now classified vary widely in their structure and habits, some being adapted to living in trees, others for life upon bushes and grass, others for cave and burrowing life and still others becoming social parasites, living in the nests of ants and obtaining their food from their hosts. As adaptations for the various modes of life have taken place certain phases of behaviour have kept pace and now present as many aspects as the varied structures and habits of the insects themselves.

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*The writer is indebted to Dr. A. S. Pearse, of the University of Wisconsin, for constant supervision of the work, to Dr. Wm. S. Marshal for suggestions and references to literature and to Mr. R. A. Muttkowski for a critical reading of the paper.

One of the most important of these special phases is that which attends the breeding activities and it is mainly with this aspect that this paper is concerned. It is impossible to describe the reproductive habits of all the Orthopteran forms as literature does not exist which would give the desired information. The activities of enough forms have been described, however, to permit a general comparison and a few generalities from the evidence thus presented.

The series of movements into which the entire process of reproduction may be divided will be considered separately and will be compared as units through the different families.

MOVEMENTS PRELIMINARY TO COPULATION. SEX DISCRIMINATION.

In some of the Orthoptera the movements preliminary to copulation are exceedingly simple. In others there is a complicated series of activities. Behaviour is the only criterion by which we may judge sex discrimination. It has been suggested that any movement which would indicate excitement after the two animals have come within sensing distance of each other might indicate recognition of sex. It must be borne in mind, however, that some of the Orthoptera are in a state of continual excitement during the breeding season, especially is this the case with males which have once copulated. In this state of excitement males will seize other males, members of other species or even a stick to which the abdomen of a female has been attached, so that it is not safe to base sex discrimination upon this one peculiarity of behaviour. On the other hand there is an entire lack of movements that would indicate excitement in some forms. Here the problem of sex discrimination is just as puzzling. No general statement in regard to sex discrimination would hold and each case must be considered separately.

The records of the sexual activities of the Blattidæ are very meager and in no case have their habits been described in detail. The sense of hearing is obviously not a factor as there are no organs for the reception of sound. Sight plays some part, for the male is described as running about the female trailing his abdomen and attempting to induce her to become quiet, even before they have come into contact with their antennæ. The senses of touch and of odor must play some part although no statement can be made as to their relative importance.

The Mantids have a very simple courting. When a male is introduced into a cage with a female during the breeding season he approaches her, raises his thorax, lowers his head and stands in this fixed position for some time. The female apparently pays no attention to him during this performance. After introducing himself in this manner he simply mounts the back of the female and copulation takes place. All the movements which are characteristic of the courting attitude occur before any contact of the antennæ or bodies has been established, so that touch and contact-odor seem to be secondary. There are no records of one male attempting to seize another, otherwise it might be contended that the sense of sight merely guided the two animals together and that the actual discrimination depended upon contact. Since discrimination is accomplished before any contact has been established, it seems that the most important factor is sight.

The Phasmids of which the walking sticks are common representatives, have very simple preliminary movements. They are mostly nocturnal in their habits and copulation takes place at night or in very dim light. No contact seems to be necessary and if sight furnishes the male with any information concerning the sex of his mate there is no excitement to indicate the fact. Without any preliminary movements whatever, the male mounts and copulates. Stockard ('08) describes some interesting experiments in which he proves that no complex combination of the senses are required for accomplishing sex discrimination. He cut off the end of the female's abdomen and fixed it to a stick which had been furnished with wire legs and it was found that the male copulated with this piece of abdomen quite as readily as with the normal female. Stockard also maintains that the experiment proves that no response on the part of the female is necessary to induce the male to copulate.

The Acrididæ or short-horned grasshoppers include a great number of genera and species which show a wide variation in their structure and a lesser degree of variation in their behaviour. A more or less constant type of behaviour preliminary to copulation, however, makes it appear that sex discrimination is accomplished in the same manner for the entire group. One factor in the ordinary behaviour of the Acrididæ which may be of some significance for mating seems to have been entirely disregarded. Most of the insects have organs for the reception of sound. During flight a dry crackling sound is made by the wings and there is a brilliant display of color. It seems reasonable that organs for making and receiving sounds which play so important part in the sexual activities of the Locustidæ and of the Gryllidæ should not be without a similar function here. The usual movements of the male of the Acrididæ consist of a few convulsive jerks of the body as he sights the female, followed by a creeping toward her until he is within springing distance. Some investigators have stated that the male will spring upon the female from a distance of three or four feet. In the Tettigidæ (grouse locusts) this process is modified somewhat. The male does not spring but, creeping toward the female, he makes a rush and mounts from the side. It is not uncommon for males of one species to spring upon other males or for males to mate with the females of an entirely different species. Species differing as widely as Hippiscus rugosum and Melanoplus femur-rubrum have been found in copulation. These facts suggest that sex discrimination and even species discrimination is of a low order in this group. Sight and possibly sound furnish the stimulus for the beginning of the preliminary movements, but an actual body contact seems to be necessary for a final discrimination of sex.

The Locustidæ with their great variety of habits and structure furnish some of the most interesting variations in their preliminary movements. Some are nocturnal; some are diurnal; some are winged; some are not; some have very complex movements attending their copulation, some mate very simply. Some forms like the katy-did have membraneous organs in the wings for producing sounds. The shrilling of the male as he attempts to call the female to him is one of the most common sounds of the late summer nights. When a female has been induced to approach the male stops shrilling and the two indulge in a preliminary fencing with the antennæ. Here we may assume that the sense of hearing was the first factor used in bringing the two sexes together. The sense of sight evidently does not play an important part here. In the Mormon Cricket (Anabrus simplex), however, sight is apparently the most important factor while hearing plays a secondary part. Anabrus is diurnal and congregates in great numbers on the prairie during the breeding season. The preliminary movements have not been observed but since the only sound uttered is a faint squeak, hearing does not seem to be so important. Among the Locustidæ are found species which are not only wingless but have no means of making sounds. These are nocturnal and representative. Ceuthophilus stygius, a species living in the caves of Indiana, has eyes that have become somewhat rudimentary. Since it breeds "far back beyond the reach of any rays of light," (Blatchley, '02) and is devoid of hearing organs, the only senses left to it for its sexual activities are those of smell and touch. In Ceuthophilus latens the writer found that although the eyes are well developed they are not used in the sexual activities of the animal, sex discrimination depending upon contact and possibly odor. In the Locustidæ then, sex discrimination is accomplished in some cases by contact (perhaps "contact odor") alone, in others by contact and sight and in still others by contact, sight and hearing.

The true crickets, or Gryllidæ, present nearly as wide a variation in their preliminary movements as do the Locustidæ. Chirping is a common habit with both the nocturnal and the diurnal crickets and is without doubt a sex call. In some of the nocturnal forms the sense of sight is evidently used but little and the sense of hearing is relatively important. The field and ground crickets have similar copulating habits. After a female has approached in response to the call of the male the usual fencing with the antennæ ensues and then the male, turning around and raising his wings, invites the female to mount. The tree cricket (Oecanthus) has been much observed and its habits described in detail. The female becomes greatly excited upon hearing the call of the male and in going to him in response to the call seems to be directed by the sound. (Jensen, 1908.)

The mole cricket (subfamily Gryllotalpinæ) breeds underground in tunnels which it constructs. (Baumgartner, '10.) Although it is obliged to carry on all its mating activities in the dark, the loss of opportunity to use the sense of sight is compensated for by the presence of a chirping organ in the female. She answers the call of the male until they have come into contact, and the problem of their uniting is simplified.

Sex recognition in the Gryllidæ is accomplished in all cases with the aid of the sense of hearing and in some without the possibility of aid by sight. How much of a part actual contact plays it is difficult to say, but the movements that would indicate a sexual excitement frequently are begun with the aid of no other sense than that of hearing. In all the families previously mentioned, except the Locustidæ, the female is a passive party in the process of copulation. In the Locustidæ she plays an active part in coming to the male in answer to his call. In the Gryllidæ she must take a still more active part and actually mount the back of the male before copulation can take place. It is a far cry from the Phasmid in which the female is so passive that the male will copulate with her abdomen which has been fastened to a stick and the female of the cricket which must not only find the male but even mount his back. Little power of discrimination would be conceded to the female of the Phasmid while in the cricket it appears that the female must have a highly developed discrimination. Since in the Phasmid it would be simply lost motion for the male to go through a series of complicated movements before such an unresponsive female, no such movements have been developed and copulation is very simple. In the cricket, on the other hand, the male must first make his whereabouts known and must then demonstrate his sex before the female will mount. Sex discrimination in the female and complication of preliminary movements have developed hand in hand.

COPULATION.

Under this topic will be discussed mainly the relative position of the bodies of male and female during copulation, the duration of copulation and the method of transfer of spermatozoa.

Since in the Cockroach the process is so rapid that the details cannot be followed, it can only be said that the male shoves his body under that of the female and accomplishes the transfer of spermatozoa in a few seconds.

The male Mantid simply mounts and copulates sometimes retaining his position for as long as seven hours. The spermatozoa are transferred directly to the oviducts and if there is any spermatophore present it is not visible externally. The habit of cannibalism is highly developed among the Mantids. If a pair is kept in captivity during their copulation, the female will invariably devour the male, although he is usually given a respite of an hour or so. Not infrequently, however, the male is devoured during the actual process of copulation. This has been observed in nature as well as in animals kept in captivity. Fabre thinks that this habit is a relic of the Carboniferous period when the Mantid was one of the few insects and when there would be a natural dearth of food. Then the male was habitually devoured as the most available source of food. A female will copulate with as many as seven males in a single season.

Copulation is as simple in the Phasmids as it is in the Mantids. The male mounts the back of the female and curling his abdomen under and to one side of that of the female he effects the union. Copulation lasts for several hours.

The method of copulation in the Acrididæ is fairly constant. The male, after assuming his position upon the back of the female, bends his abdomen to one side and under that of the female and copulates. Copulation between a single pair lasts for hours and sometimes as long as two days. There is no spermatophore, the spermatozoa being transferred directly to the oviducts by a bifurcated intromittent organ.

In spite of the great variety exhibited in the structure and habits of the Locustidæ there is a fairly constant mode of copulation. It may be termed an "end to end" position. In some cases both of the animals are in a vertical position on grass stems; sometimes the male is curled beneath the female, or even standing on his head. In the case of Ceuthophilus both animals stand upright, facing in opposite directions, while the end of the abdomen of the male is inverted and grasps that of the female by the subgenital plate. This may be taken as a typical position while the others are variations necessitated by circumstances. The mating pair may be located upon parallel or upon diverging stems, upon the ground in a horizontal position or the female may be running about dragging the male in any position. Copulation is of short duration, generally lasting a few minutes and the spermatozoa are transferred by means of spermatophore. This spermatophore when visible externally appears as a lobed membranous sac which is translucent at first but becomes opaque after a short exposure to the air. It appears shortly after the union of the two animals and is quickly transferred by the male to the vulva of the female where it hangs until the contained spermatozoa have made their way into the oviducts.

The relative position of the bodies of the male and the female is constant throughout the entire group of the Gryllidæ.

The female mounts the back of the male and a spermatophore is fixed to her vulva by the male. The transfer of the spermatophore takes only a few minutes but the animals remain in their positions for a short time before separating. As soon as she is free from the male the female begins to gnaw at the spermatophore and it seems that nature has provided a special organ for keeping her attention diverted long enough to allow the spermatozoa to enter the oviducts. At the base of the male's wing is located a gland which exudes a viscous liquid which is evidently very palatable to the female for she gnaws at it constantly during copulation, and is kept occupied for some time after the spermatophore has been transferred.

From the evidence drawn it is safe to say that each family of the Orthoptera has a fairly constant mode of copulation, and that insofar as any specialization is shown it has its greatest development in the Locustidæ and in the Gryllidæ.

OVIPOSITION.

The process of egg-laying is very simple in some of the Orthoptera and complex in others.

The oviposition of the Cockroach may be considered a very specialized type. Sixteen eggs are deposited by the female in a horny capsule which is secreted inside of her body. Some of the Cockroaches deposit this capsule as soon as it is formed, while others carry it about, partially protruding from the body, until the young are nearly ready to hatch. Then it is deposited in some convenient crevice. The capsule is a brown, horny structure which is in the shape of a flattened oval measuring about 12 mm. in length and 6 mm. in width. It is furrowed by a series of fine annulations, and provided with a lateral notched carina. The eggs are arranged in two symmetrical rows of eight each.

Egg-laying among the Mantids is a very complicated process. A single female lays a great many eggs, all of which are deposited at one time and enclosed in a fibrous öotheca. The öotheca is attached to a twig, a stone, or to any suitable object that may be at hand. In making the ootheca a small amount of a viscous liquid is extruded from the oviducts and the genital plates immediately begin whipping the liquid into a foam. More liquid is extruded and the whipping continues.

From time to time the abdomen is buried deep in the mass, and it is supposed that actual egg-laying occurs at this time. The time required for completion of the egg case is about two hours. The öotheca as it is finally left by the female is a rough, oval structure composed in its interior of horny material which gives place near the surface to an alveolar structure. The outer covering resembles tough silk in its consistency. The eggs are arranged in regular tiers in the center of the case. The entire structure is an admirable one for resisting the rigors of the weather as well as the attacks of insects and of parasites.

The Phasmids have a type of egg-laying that appears to be most simple. The eggs are simply discharged at random and fall to the ground. The fact that a fairly well developed ovipositor still persists in the Phasmids which practice this random method of oviposition seems to indicate that this method of deposit is a recently acquired one.

When the female of the Acrididæ is ready to lay her eggs, she brings forward the end of her abdomen, and inserting it into the ground at a sharp angle to the axis of the body, she works the valves of the ovipositor and shoves with the abdomen until the entire posterior end of the body is buried in the ground. Having accomplished this, she fills the cavity which she has made with eggs arranged in oblique columns and at the same time she exudes a viscous liquid which fills the hole and binds the eggs together. Some of the grouse locusts on account of their small bodies and short abdomens can construct only shallow burrows. Such animals frequently lay in moss where the eggs are protected by their resemblance to seeds found there.

The Locustidæ and the Gryllidæ present a wide variation in their manner of egg-depositing. The Katydids live mainly on bushes and trees and deposit their eggs there. In some instances the eggs are glued to the side of a twig and in others they are stuck to the edge of a leaf, or even enclosed in the end of a leaf which has been split for this purpose. When a female is ready to deposit her eggs, she roughens the surface of the twig and removes any buds or other projections. Then bringing forward the end of her scimiter-shaped ovipositor she guides it into the correct position by means of her palpi and jaws and then emits a glue-like liquid which adheres to the twig. The egg then appears shiny black at first, but turns gray later and is glued fast so that it lies at a slight angle to the twig.

The process is repeated, each egg overlapping the preceding one, until a row has been deposited. The eggs are oval but are very much flattened, resembling hemp seeds in shape. The cone-headed grasshoppers have blade-like ovipositors of different shapes, some being short and curved, others very long, straight and pointed. These serve for inserting the eggs between the leaves and stems of grass upon which the insects live. Ground dwelling Locustidæ such as Anabrus and Ceuthophilus, have their ovipositors modified for piercing the ground. That of Ceuthophilus is slender but strong and is equipped with five teeth at its apex.

The ground and field crickets lay their eggs, singly or in groups of from two to five, in the ground. The long needle-like ovipositor is admirably adapted for thrusting into the ground. The tree crickets (Oecanthinæ) have retained the long, needle-like ovipositor but have modified its use to suit their changed habitat. Stems containing pith are usually selected for egg receptors, raspberry stems being most favorable. The female begins operations by biting the twig and roughening it so that the ovipositor may gain an entrance. The ovipositor is then brought up, placed upon the roughened spot and by vigorous working of the blades and thrusting with the abdomen, the twig is pierced to the depth desired. The egg is deposited and crowded tightly into the hole by the ovipositor after which it is covered and left. The same process is repeated until the twig contains a long row of eggs in the pith almost perpendicular to the long axis of the twig.

The mole crickets do not have a well developed ovipositor. The eggs are deposited by simply dumping them in a heap in one of the subterranean chambers. Contrary to the habits of the other crickets, however, the eggs are watched and cared for until they hatch.

On the whole the Acrididæ may be considered to have the most generalized type of egg-laying. The Blattidæ and the Mantids have been specialized in the direction of highly developed egg-cases while the Locustidæ and the Gryllidæ have become specialized in the habit of laying the eggs singly or in small groups, each single egg or group in its own prepared cavity.

SPECIALIZED AND SIMPLE TYPES OF REPRODUCTIVE BEHAVIOUR.

In considering the different aspects of the reproductive behaviour, (preliminary movements, oviposition, etc.), the Acrididæ appear to be the least specialized. The Cockroaches and the Mantids are specialized in the habit of constructing egg capsules and cocoons. The Locustidæ and the Gryllidæ have developed their preliminary movements to a great extent and also have a specialized type of oviposition, but different from the Cockroaches and the Mantids. The Acrididæ seem to be specialized in neither regard and occupy a somewhat intermediate position as regards egg-laying and preliminary movements.

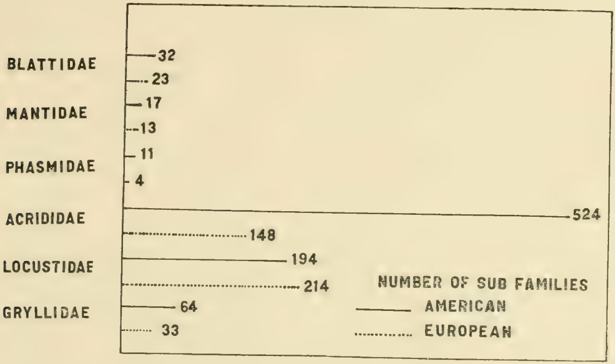

FIG. 1. Diagram to illustrate effect of specialization upon the number of sub-families in each group of the Orthoptera.

It is a well known fact that specialization in any habit, especially in breeding habits confines the animal to a more limited field and lessens its chances for adjusting itself to changes in environment. Consequently the animal which has the more general habits can occupy the larger general field and so have a larger representation. Figure 1 represents the total number of subfamilies in each group of the Orthoptera in the Holoarctic realm. The Acrididæ far outnumber the other groups. Locally one subfamily may predominate as it finds conditions favorable to its mode of specialization; but in general, non-specialized conditions will prevail, and it is the type of animal which has the least degree of specialization that will have the largest representation. It is possible that conditions have arisen in Europe that have been temporarily very favorable to the type of specialization of the Locustidæ, causing them to attain to greater diversity than the Acrididæ in that region or the Locustidæ in America.

The Phasmids and the Mantids have their greatest development in the tropics. Consequently they are poorly represented in the more generalized temperate climates of Europe and of the United States.

AN ATTEMPT TO CLASSIFY THE ORTHOPTERA ACCORDING TO THEIR REPRODUCTIVE BEHAVIOUR.

Figures 2, 3 and 4 are schemes based upon one or two factors of reproduction while Figure 5 represents a classification based upon all the factors collectively.

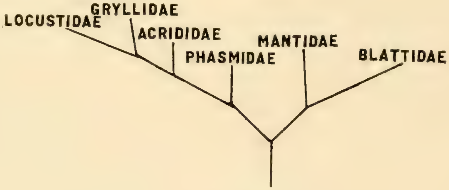

*Fig. 2. Classification based upon specialization of the ovipositor, Rudimentary ovipositor in Blattidæ and Mantidæ, intermediate development in Phasmidæ and Acrididæ, maximum development in Gryllidæ and Locustidæ.

In Figure 2 the classification is based upon the amount and direction of specialization of the ovipositor. The first division separates the Mantids and the Cockroaches from the others because of the lack of an external ovipositor. In both forms the ovipositor is relatively undeveloped. The Phasmids are included with the Acrididæ, the Gryllidæ and the Locustidæ because they have a fairly well developed ovipositor although it apparently is not used. The Acrididæ are separated from the Locustidæ and the Gryllidæ because of their relatively short and undeveloped ovipositor. The Locustidæ and the Gryllidæ as a whole have highly specialized ovipositors although some have suffered an almost complete loss of the organ due to their change of life. Reading from right to left we have a more or

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*In Figs. 2, 3, 4 and 5 direction and extremes of factors used in classification are indicated in horizontal plane.

less regular sequence; first, the non-development of an external ovipositor; second, an ovipositor developed but nonfunctional; third, a comparatively unspecialized ovipositor and lastly, a highly specialized and functional ovipositor.

The classification in Figure 3 is based upon the presence of a definite egg-capsule or the approach to it in those forms which do not possess it. As in Figure 2 the Mantids and Blattids stand apart from the other forms being divided from the other forms because of their possession of an egg capsule or öotheca. The Locustidæ and the Gryllidæ again occur at the other extreme, because they lay their eggs singly or in masses of only two or three. Again the Acrididæ occupy an intermediate position because they resemble the Blattidæ and the Mantidæ in laying their eggs all at once but in not having a definite egg capsule. The position of the Phasmids in this classification is doubtful. The fact that they choose no special place for depositing their eggs and that they deposit them in a very loose manner, indicates a rather low degree of specialization. They have been placed near the Locustidæ and the Gryllidæ because they resemble these families in depositing their eggs singly.

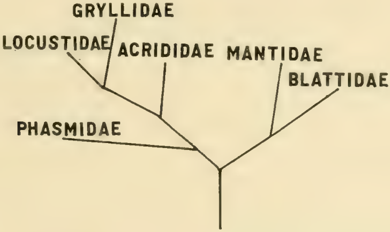

FIG. 3. Classification based upon the occurrence of an egg capsule. Mantidæ and Blattidæ having a definite ootheca are placed by themselves. Gryllidæ and Locustidæ laying eggs singly are placed at the opposite extreme. Acrididæ, laying eggs in compact mass are placed between. Phasmidæ are placed near Acrididæ because eggs are all discharged at once. Since they have no approach to an ootheca they are inclined to the left extreme.

In Figure 4 three factors are considered in the classification of one of the stems established in Figures 2 and 3. These factors are the presence or the absence of a spermatophore, the relative position of the bodies during copulation and the duration of copulation. The three factors are intimately associated.

Long duration of copulation, the absence of a spermatophore and the superposition of the body of the male during copulation divides the Phasmids and the Acrididæ at once from the Locustidæ and the Gryllidæ. Minor peculiarities in these factors permit a division between the Acrididæ and the Phasmids. The Locustidæ and the Gryllidæ have a short duration of copulation, and a spermatophore which is usually visible. The Locustidæ and the Gryllidæ may be divided upon the ground that there is a superposition of the body of the female in the Gryllidæ and an "end to end" position of the bodies in the Locustidæ. The mole crickets may be divided from the other Gryllidæ because of their peculiar modification of the usual body position.

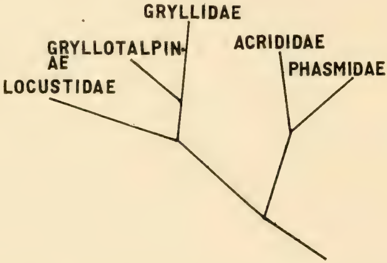

Fig. 4. Classification based upon the development of spermatophores in those forms showing an inclination toward this structure. Acrididæ and Phasmidæ, having sperm masses resembling spermatophores but not enclosed in a membrane, are placed at one extreme. Gryllidæ have definite spermatophore, but highest development is reached in Locustidæ, which are placed on the left extreme.

An attempt is made in Figure 5 to summarize the factors that have been named as well as some additional ones. The main division is made because of the following facts: The Blattidæ and the Mantidæ have a definite egg capsule or ootheca; they have no development of an external ovipositor for inserting eggs into the ground or into twigs and they neither produce sounds nor have organs for the reception of sounds. The other groups are united because they possess ovipositors, because they have organs for producing and receiving sound and because they do not lay their eggs in a capsule. The position of the Phasmids is doubtful but a consideration of all their breeding habits will place them in the position shown, nearer to the Acrididæ than to the Mantidæ. The Blattidæ and the Mantidæ may be divided because of the peculiar manner in which each constructs its egg case. A further subdivision of the Blattidæ is made to include the myrmecophilous forms. The stem including the Acrididæ and the Phasmidæ is separated off because of the following factors: These two forms have a relatively poor development of the ovipositor, and a superposition of the body of the male during copulation. Eggs are laid all at one time, sounds are produced which consist of a crackling of the wings, hearing organs are present and are located in the base of the abdomen. In the Locustidæ and the Crickets on the other hand the ovipositor is well developed and specialized, the bodies are found in various positions during the copulation but there is no superposition of the body of the male, eggs are laid singly or in masses of two or three, sounds produced consist of chirps, and the organs for the reception of sounds are located in the anterior tibia. The Acrididæ and the Phasmids are separable because of differences already mentioned. A subdivision of the Locustidæ is made because some forms have suffered a degen-

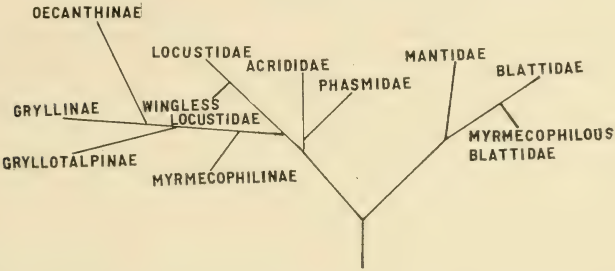

*FIG. 5. Classification based upon summary of factors in three preceding schemes. Right extreme indicates presence of definite ootheca, long duration of copulation, superposition of body of male during copulation (in Mantidæ), absence of organs for production and reception of sounds and the absence of an ovipositor. The left extreme indicates a complication of movements prior to copulation, absence of an ootheca, eggs laid singly, superposition of body of female during copulation, presence of stridulating organs and organs for the reception of sound. Forms placed in various intermediate positions show a lesser degree of specialization.

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*Horizontal plane indicates general direction and extremes of summary of factors and processes used in classification. Lines inclined upward indicate development and specialization of organs and processes, while lines inclined downward indicate degeneration or loss of organs. Extent of lines indicates to some degree the amount of development or degeneration.

eration of those very factors which mark them off from the other groups. The forms that have entirely lost their wings have lost their capacity for producing sounds. In Ceuthophilus the organs for the reception of sound have also been lost. The factors by which we may divide the Locustidæ from the Crickets are not so conspicuous. The modification which the ovipositor has undergone in each group will suffice for their division. The relative position of the bodies of the male and of the female during copulation is another factor which may divide them. The diversity found among the crickets makes further subdivision possible in that group. The activities of the field crickets may be regarded as the most typical for the Gryllidæ. The tree crickets (Oecanthinæ) being specialized in their manner of ovipositing are given a separate standing. The mole crickets, because of the absence of the ovipositor, the changed manner of depositing the eggs, and because of the development of a chirping organ in the female, have been placed in a separate division. Little is known of the reproductive habits of the myrmecophilous crickets and Blattids. In European forms only the females have been discovered. Both males and females, however, have been found in an American form by Wheeler. (Wheeler, 1900.) The reproductive activity must differ somewhat from the typical mode. Consequently they are given a separate rating as indicated in the diagram.

Having made such a classification it must be admitted that the behaviour of each group depends to some extent upon structural characteristics so that the classification really rests upon morphological characters, the basis adopted by taxonomists for classification. The structural characteristics have been used, however, only when they have some intimate connection with the reproductive behaviour.

A glance at the ancestral tree of the Orthoptera, (Fig. 6), will show some striking resemblances to the classification based upon the reproductive behaviour (Fig. 5). The fossil evidence bearing upon the ancestry of the Orthoptera has been thoroughly worked out by Anton Handlirsch ('08), and a genealogical tree constructed to show the relations of the different families. Figure 6 represents the essentials of his scheme. The Blattidæ and the Mantidæ are entirely divided off as early as the Carboniferous period. The stock from which the other groups have arisen was divided into two rather definite divisions, one including the Phasmids and the Acrididæ with some others that are not being considered here for want of information concerning their habits, and the other the Locustidæ and the crickets. The Gryllotalpinæ have arisen in comparatively recent times from the typical stock of the Gryllidæ.

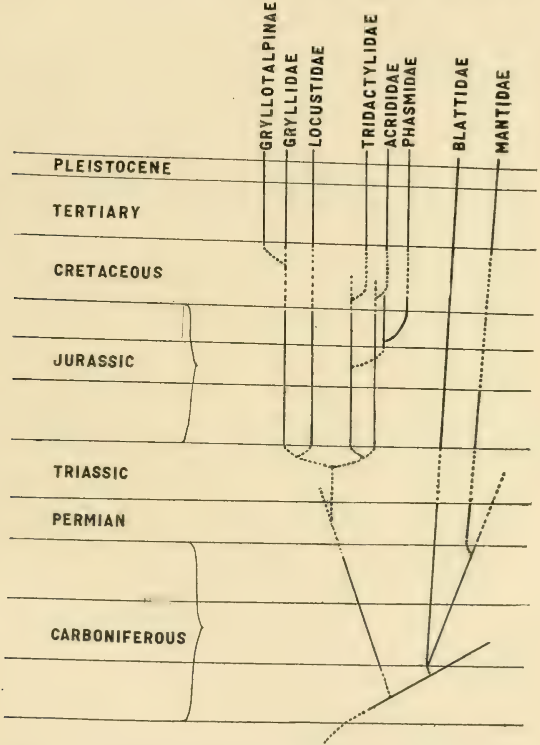

FIG. 6. Scheme indicating the phylogeny of the Orthoptera.

A comparative study of Figures 5 and 6 suggests that the agreement between the diagrams is not a mere coincidence. From a common ancestral stock specialized types have arisen, some persisting and others perishing. We may assume that the variations arose, first, because the animals were subjected to a new environment and the necessary modifications in the behaviour caused modifications in structure, or that variations in structure arose by orthogenesis and the animals were called upon to find a suitable environment or perish. The latter assumption seems to be the most reasonable. The agreement between the two figures also suggests that the more fundamental modifications in structure and in behaviour have been fairly constant since their origin.

SUMMARY.

1. Movements preliminary to copulation are fairly constant for each group of the Orthoptera and vary from very simple (Mantidæ, Phasmidæ and Acrididæ) to complex (Blattidæ, Gryllidæ and Locustidæ).

2. There is a sex discrimination in the males of all forms. The female plays an aggressive part and displays a discrimination of sex in some groups while in others she is absolutely passive.

3. There is a typical mode of copulation for each family of the Orthoptera. In the Mantidæ, the Phasmidæ and the Acrididæ there is a superposition of the body of the male. In the Blattidæ and the Gryllidæ there is a superposition of the body of the female. In the Locustidæ there is an "end to end" copulation.

4. Families represented by the least number of subfamilies are highly specialized while those represented by the largest number of subfamilies have a generalized type of reproductive behaviour.

5. A comparison between a classification based upon the reproductive behaviour and one based upon pæleontological evidence shows a striking agreement and suggests that the different types of reproductive behaviour have been fairly constant since their origin.

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THE CLASSIFICATION OF THE PUPÆ OF THE SATURNIIDÆ.*

Edna Mosher.

A short discussion of the characters of the pupæ of the superfamily Saturnioidea was given in a preceding paper, Annals Entomological Society of America, Vol. VII, pp. 277-8, including a key for the separation of the three families. Two of the families, the Ceratocampidæ and Hemileucidæ were discussed in that paper, and the third, the Saturniidæ, will be considered here. Plate V, included in this paper shows some of the more important structures of the Ceratocampidæ and Hemileucidæ.

The general characters of the family Saturniidæ are as follows: Body with abdominal segments 5 to 7 capable of being telescoped, antennæ broadly pectinate throughout, or nearly so, the stem of the flagellum distinct and raised above the level of the pectinations, varying greatly in the sexes, always broader and usually longer in the male; maxillæ, measured on the meson,† never more than one-third the length of the wings; the exposed portion of the tibiæ and tarsi of the first pair of legs, and the tips of the second pair of legs with their lateral margins adjacent on the meson, never with the distal ends of the tarsi of the first and second pairs of legs meeting obliquely on the meson; first pair of wings with the anal angles broadly rounded, and always reaching the caudal margin of the fourth abdominal segment on the ventral surface; second pair of wings produced around the anal angles of the first pair of wings and usually forming prominent angles on the fourth abdominal segment, always extending at least a short distance along the ventral margin of the first pair of wings; metathorax without distinct oblong tubercles one-third or more the width of the segment; suture between the seventh and eighth abdominal segments never deep with distinct crenulations on its margins; distinct cremaster never present; pupæ always found in cocoons.

Of the family Saturniidæ, the pupæ of eight genera have been described in the following pages. They may be separated by the following key:

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*Contribution from the Entomological Laboratories of the University of Illinois, No. 46.

†The maxillæ are measured from the distal margin of the labrum to their distal end (Fig. 14, a, b). The wings are measured from the same point to their caudal margin (Fig. 14, a, c).

A. Body never cylindrical, but tapering gradually from the middle as in Fig. 13, the lateral margins of the movable segments never approximately parallel; caudal end of body usually with stout curved spines.
  B. Tenth segment never flattened into a transverse plate, with the caudo-lateral angles produced into short lobes.
    C. Caudal end of body without spines; body surface with slightly wavy, transverse ridges, with distinct furrows between; mesothorax never with a prominent tubercle at the base of each wing. *Copaxa.*
    CC. Caudal end of body with stout, curved spines; body surface never with slightly wavy, transverse ridges with distinct furrows between; mesothorax with a prominent tubercle at the base of each wing.
      D. Lateral aspects of the cephalic margins of abdominal segments 5 to 7 never with sharp, slightly wavy, transverse ridges with distinct furrows between; caudal end of body with an oval area set with slightly curved spines, usually arranged in two groups and nearly all pointing outwards. *Telea.*
      DD. Lateral aspects of the cephalic margins of abdominal segments 5 to 7 covered with sharp, slightly wavy, transverse ridges with distinct furrows between; caudal end of body deeply rugose, with a slight concavity containing a circular group of strongly recurved spines. *Tropaea.*
  BB. Tenth segment, viewed dorsally, a transverse plate, concave on the caudal margin, the caudo-lateral angles produced into lobes, the segment strongly concave in ventral view, with five short, curved spines inserted close together in the caudo-lateral margin of each lobe. *Agapema.*
AA. Body cylindrical in outline, as in Fig. 14, the lateral margins of the movable segments approximately parallel; caudal end of the body never with stout curved spines, but sometimes with short, straight ones.
  B. Maxillae, measured on the meson, always one-fourth or less the length of the wings, the proximal two-thirds of their margins never strongly concave; first pair of wings with their anal angles on the cephalic margin of the fourth abdominal segment or caudad of that portion of the segment.
    C. Maxillae, measured on the meson, less than one-fifth the length of the wings; antennae of males with the sides tapering gradually to a pointed tip.
      D. Both eye-pieces never visible in either sex; caudal end of abdomen never with a band of coarse setae, sometimes with a few very short, straight spines.
        E. Glazed eyepiece visible in both sexes; caudal end of abdomen with a few very short, straight spines. *Eupackardia.*
        EE. Glazed eyepiece never visible in either sex; caudal end of abdomen never with short, straight spines. *Callosamia.*
      DD. Both eyepieces visible in either sex; caudal end of abdomen with a transverse band of coarse setae. *Rothschildia*
    CC. Maxillae, measured on the meson, never less than one-fifth the length of the wings; antennae of males with the sides approximately parallel for the greater part of their length, tapering rapidly to a blunt, rounded tip; a small portion of glazed eyepiece always visible in the females. *Samia.*
  BB. Maxillae, measured on the meson, always more than one-fourth the length of the wings; the proximal two-thirds of the lateral margins of the maxillae concave; first pair of wings with their anal angles on the third abdominal segment, opposite the second pair of abdominal spiracles. *Philosamia.*

Genus **Copaxa** Walker.

Body tapering at cephalic end; face parts scarcely elevated above the surface of the body; antennæ pectinate throughout, the stem of the flagellum slightly elevated above the pectinations; glazed eye-piece visible in the female; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture distinct; maxillæ, measured on the meson, about one-seventh the length of the wings; tarsi of the first pair of legs adjacent on the margin in the female, covered by the antennæ in the male; second pair of legs not visible; median thoracic line distinct, sometimes elevated on the prothorax, faint on the mesothorax and metathorax; caudal part of mesonotum and metanotum not depressed adjacent to wings; wings with their distal margins slightly elevated above the dorsal surface of the body; first pair of wings with their anal angles broadly rounded; second pair of wings visible around the entire dorsal margin of first wing and produced below the anal angle to form a prominent angle opposite the third abdominal spiracle, but not reaching the caudal margin of the fourth abdominal segment; abdominal segments 8 to 10 distinctly segmented, tapering rapidly to form a cone.

This genus is found in Mexico and southward. The cocoons are brown, composed of two layers and are much like those of *Agapema galbina*. The outer layer is very thin and coarsely reticulate, usually attached to a leaf. The inner layer is much thicker, finely reticulate, and the cocoon has an opening at the end, with loose fibers for the emergence of the moth.

Copaxa lavendera Westwood.— Color variable, usually yellowish brown to black, marked with darker brown, or dark brown to black, with traces of yellowish brown; face parts with fine, indeterminate longitudinal striations, appendages and wings with indeterminate transverse striations, remainder of body surface with slightly wavy, interrupted ridges, mostly transverse, with distinct furrows between; antennæ of male slightly raised above the level of the wings, the length about two and three-quarters times the width, the sides approximately parallel for the greater part of the length, tapering to a point at distal end and lying adjacent on the margin for a distance equal to its width; antennæ of female not raised above the level of the wings, the length three and one-half times the width, tapering to a point at the distal end, the tips meeting on the meson over the tips of the first pair of legs; labrum variable, the width a little greater than the length, usually five or six sided, slightly tuberculate, and broadly rounded or slightly bilobed at the distal end; maxillæ triangular in outline or somewhat heart-shaped, the median length slightly less than the greatest width; spiracles free. Length, abdomen retracted, 30-32 mm., expanded, 33-35 mm., girth, 38-45 mm.

Genus **Telea** Hübner.

Body blunt at cephalic end; abdominal segments 1 to 4 rounded out above the margin of the body dorsad and forming a distinct hump, segments 5 to 7 distinctly decreasing in size and caudal margin of segment seven joining cephalic margin of segment eight with only a slight indentation between; antennæ pectinate throughout, varying greatly with the sexes, the stem of the flagellum in both always less than one-third the total width; eye-pieces not visible; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture distinct; maxillæ, measured on meson, about one-fourth length of wings; legs in the male covered by antennæ, in the female tarsi of first pair and tips of second pair adjacent on the meson; median thoracic line carinate on all segments; mesothorax with a prominent tubercle at base of wings;* caudal part of mesonotum and metanotum depressed adjacent to the wings; wings with their distal margin raised above the dorsal surface of body; dorsal cephalic margins of abdominal segments 5 to 7 form a heavy raised line extending laterad and cephalad of the spiracles to the proleg scars on the ventral surface; abdominal segments 7 to 10 tapering rapidly, forming an oblique convex cone-shaped piece; tip of abdomen with a small oval area set with fifteen or more stout, black, slightly curved

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*Mesothoracic tubercles are found in the pupae of many genera, but are especially prominent in the case of *Tropaea luna* and *Telea polyphemus* (Fig. 11, w. t.), where at the proximal ends of the wings they differed so much in shape and size from any others noticed in the study of pupae, that they were investigated and each found to contain a prominent spine. This spine is used to cut the cocoon to allow the imago to escape and was found in the imagos of all genera of Saturniidæ studied, but especially well developed in the genera previously mentioned. A study of the preimago showed that this spine was an outgrowth from one of the wing sclerites, the third axillary of Snodgrass. In *Telea polyphemus* (Fig. 12), there is also a smaller spine cephalad of the large one.

spines, usually arranged in two small groups and nearly all pointing outwards.

This genus consists of a single species, *Telea polyphemus*, found in all parts of the United States. Their cocoons consist of a thick, firm layer, never "papery," like those of *Tropaea luna*. The cocoons are pale grayish tan in color, ovoid in shape, blunt at the ends and usually fastened between two leaves. It never has an opening at the end with loose fibers across it, as many cocoons have. It is found suspended from twigs where it often fastens the leaf to a tree and is also found on the ground among the fallen leaves.

Telea polyphemus Cramer (Figs. 11 and 13).—Color yellowish brown, with darker brown around margins of spiracles, and appearing at various places on surface as the age increases; face parts not elevated, always white between the antennæ, the white strip narrowing down to the proximal margin of the labrum and concave on its lateral margins; prothorax and mesothorax with faint transverse striations, remainder of body surface smooth, with the exception of longitudinal wrinkles on the metathorax and first abdominal segment and some slight dorsal impressions; antennæ of male five-sixths the length of wings on the meson, length twice the width; meeting on the meson for more than half their length; antennæ of the female two-thirds the length of wings on the meson, length three times the width, separated by the legs and ending slightly below tips of the first pair; labrum variable, tuberculate, generally five or six sided, the distal margin either slightly or deeply bilobed; maxillæ triangular in outline, the mesal length greater than greatest width; mesothorax with wing tubercles prominent, broadly elevated, with a distinct apex marked by an angular furrow on the caudo-mesal margin; first wing with its anal angle broadly rounded, below cephalic margin of fourth abdominal segment; margin of second wing entire in the female, slightly emarginate in the male, visible along entire dorsal margin of first wing, and produced below anal angle of first wing, extending about two-fifths of the distance across its caudal margin; mesothoracic spiracles with their cephalic margins strongly convex. Length, retracted, 25-35 mm.; expanded, 30-40 mm.; girth, about 50 mm.

Genus **Tropaea** Hübner.

Body usually somewhat depressed; abdominal segments 5 to 7 distinctly tapering, face parts never elevated above the surface of the body; antennæ pectinate throughout, the stem of the flagellum elevated above the level of the pectinations and more than one-third the total width; invaginations for the anterior arms of the tentorium distinct; eye-pieces both visible; clypeo-labral suture distinct; maxillæ, measured on meson, about one-eighth the length of wings; about half the tibiæ and the tarsi of the first pair of legs and the tips of the second pair of legs adjacent on the meson; median line distinct on all thoracic segments; each mesothoracic spiracle about one-fourth the distance along the caudal margin of prothorax to meson; mesothorax with a prominent tubercle at base of wings and a slight depression along lateral margin of alar area; caudal part of mesonotum and metanotum not depressed adjacent to wings; wings with their distal margins not elevated above the surface of the body; abdominal segments 5 to 7 with the lateral aspects of the cephalic margins covered with sharp, slightly wavy, transverse ridges with distinct furrows between, the cephalic margin narrowed on the dorsum, the furrows extending dorsad about two-thirds of the distance between the spiracular line and the meson and ventrad less than half way between the spiracular line and the meson, the furrows usually concealed when the abdomen is retracted; abdominal segments 8 to 10 tapering quickly to form a convex cone-shaped piece; caudal end of body deeply rugose with a slight concavity containing a circular group of strongly recurved spines, the curved tips all pointing toward the center of the group.

This genus is found throughout the Atlantic States and the Mississippi Valley, and includes a single species in this country. The cocoon is ovoid, thin and "papery" on the outside, with a thin inner layer of loose fibers of silk, but it has no opening at the end with loose fibers of silk closing it, as in *Callosamia promethea*. The cocoon is usually brown in color, and is found among the leaves on the ground under the food plant.

Tropaea luna Linnaeus.—Color generally chestnut brown with an irregular white blotch extending between the proximal ends of the antennæ; face parts and exposed portion of thorax with fine indeterminate, impressed lines, the first eight abdominal segments with fine punctures more numerous at the dorsal cephalic portion of segment; antennæ of male tapering gradually until near distal end, then the mesal margin concave to tip, length two and one-half times the width, ending near the middle of exposed portion of tarsus of the second pair of legs; labrum variable, usually broadest on the distal portion, with more than twice the length, five-sided and pointed at the distal end; maxillæ with each half quadrilateral, the median length much less than the greatest width; first wing with its dorsal margin rounded from point of attachment, so that the anal angle is almost impossible to determine; second wing visible around entire dorsal margin of first wing, its margin entire, not produced to form an anal angle and extending about half way across caudal margin of first wing. Length, abdomen retracted, 30-37 mm., expanded, 37-45 mm., girth 38-50 mm.

Genus **Agapema** Neumoegen & Dyar.

Body tapering at cephalic end, abdominal segments 8 to 10 never forming a cone; antennæ pectinate throughout, tapering to a point at the distal end; invaginations for the anterior arms of the tentorium distinct; eye-pieces both visible; labrum elevated above the surrounding surface, clypeo-labral suture obsolete; maxillæ measured on meson about one-seventh the length of wings; median thoracic line distinct on prothorax and mesothorax, sometimes on the metathorax; strongly carinate on prothorax; caudal portion of mesonotum and metanotum slightly depressed at base of wings; wings with their distal margin slightly raised above the dorsal surface of body; lateral aspect of the cephalic margins of abdominal segments 5 to 7 with sharp, slightly wavy, transverse ridges with distinct furrows between, the cephalic margin narrowed on the dorsum and the furrows indistinct, furrows extending ventrad to the region of the proleg scars; cremaster absent; abdominal segments with distinct depressions between the segments, excepting on the dorsum; the tenth segment, as viewed from above, a transverse plate, concave on the caudal margin and the lateral angles produced into lobes, as viewed from ventral aspect, the ventral surface strongly concave and five short, curved spines inserted close together in the lateral margin of each lobe.

This genus includes a single species in North America, *Agapema galbina*, found in Arizona, Texas and Mexico. The pale grayish tan cocoons consist of two layers, a very thin, coarsely reticulated outer layer, and an inner thicker layer with smaller reticulations, both layers having loose fibers at the cephalic end closing an opening made by the thicker walls. It is suspended by the side, as *Samia cecropia*.

Agapema galbina Clemens.—Color generally tawny or yellowish brown, with slightly darker transverse conjunctiva and margins of spiracles; entire surface except wings and antennæ, covered with fine wavy impressed lines and coarse punctures; wings and antennæ with similar lines, but much deeper impressions; face parts elevated; tips of antennæ usually lie adjacent on the meson for a distance nearly equal their width, occasionally separated by the cases for the first pair of legs; length two and one-half times width, stem of the flagellum elevated above the level of the pectinations; labrum slightly longer than broad, its distal end rounded or pointed; maxillæ with each half somewhat triangular in outline, with lateral margins concave, surface almost smooth; space between maxillæ and antennæ filled in by part of the tibia and tarsus of the first pair of legs; mesothoracic spiracles triangular, mesothorax with lateral part of alar area elevated and a smooth, rounded spot about two-thirds of the distance from the cephalic margin; first wing with its anal angle very broadly rounded on cephalic margin of fourth abdominal segment; second wing visible along entire dorsal margin of first wing, its margin entire, produced around angle of first wing, but never reaching half way across its caudal margin; first and second abdominal spiracles often partially covered by the wings. Length, abdomen contracted, from 15-25 mm.; girth, 25 mm.

Genus **Callosamia** Packard.

Body cylindrical; face parts slightly elevated; antennæ pectinate throughout, tapering gradually to a point at the distal end, the stem of the flagellum raised above the level of the pectinations and one-third the total width of the antenna; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture obsolete; maxillæ, measured on the meson, always about one-sixth the length of the wings, triangular in outline; tarsi of the first pair of legs and tips of the second pair adjacent on the meson; median line distinct on the prothorax and mesothorax; caudal portion of mesonotum and the metanotum depressed adjacent to the wings; wings with their distal margin always raised above the level of the dorsal surface of the body; first pair of wings with their anal angles rounded and opposite the cephalic margin of the fourth abdominal segment; second pair of wings visible along entire dorsal margin of first pair; abdominal segments 8 to 10 tapering rapidly to form a cone; cremaster absent.

This genus includes two species in North America. Both of these, *C. promethea* and *C. angulifera*, are found east of the Mississippi. The cocoons of *C. promethea* resemble those of *P. walkeri*, but are more common, dangling in clusters from almost every spice bush, wild cherry and many other food plants in regions where they occur. Promethea cocoons are grayish brown in color, usually darker than walkeri cocoons and cylindrical in shape, generally blunt at the caudal end. They are suspended by a long band of silk from the cephalic end which usually fastens the encircling leaf to a twig together with the cocoon. *C. angulifera* is comparatively rare and its cocoons are seldom found suspended from twigs, but are usually found among fallen leaves at the base of a tree. They are ovoid, dull brownish gray in color, with the valvular arrangement of loose fibers of silk at one end. The walls of the cocoon are thicker than promethea cocoons and more readily separated into layers.

The following table will serve to separate the pupæ of this genus:

A. Dorsal cephalic margins of abdominal segments 5–7 produced into a flange-like ridge, widest at meson and ending opposite spiracles; spiracular openings at the bottom of a lenticular depression; dorsal margin of second pair of wings scarcely bisinuate. *promethea.*

AA. Dorsal cephalic margins of abdominal segments never produced into a flange-like ridge; spiracular openings with a lenticular, elevated, smooth, rounded margin; dorsal margin of second pair of wings deeply bisinuate. *angulifera.*

Callosamia promethea Drury.—Color generally yellowish, dark brown on the middle of the back and around the margin of spiracles, sometimes on the wings; dorsal aspect of thorax and abdomen with deep, wavy, transverse striations, fine, indeterminate striations on face parts, wings and legs, the remaining surface practically smooth; dorsal cephalic margins of abdominal segments 5–7 produced into flange-like plates, widest at the meson and ending opposite the spiracles; line between segment and transverse conjunctiva elevated on dorsal aspect; tips of antennæ generally separated by second pair of legs, ending in the female half-way between the tips of the first and second pairs of legs, in the male opposite the tips of the second pair, tips of antennæ in both sexes frequently meet on meson, those of male slightly longer and wider than those of female, the length never more than three times width; no eye-pieces visible; labrum variable, broadly rounded distally; maxillæ generally smooth, sometimes separated on meson to show coxal cases beneath, length on meson equals breadth at cephalic end; margin of second pair of wings scarcely bisinuate, produced into a rounded anal angle and extending less than half way across caudal margin of the first pair; mesothoracic spiracles small; first and second abdominal spiracles partially covered by the wings; spiracular openings located at the bottom of lenticular depressions, lips of the depression smooth and glossy, and of the opening, rounded and of a different color; abdominal segments 8–10 taper rapidly to form a cone, occasionally with a button-like tip. Length, abdomen retracted, from 20–30 mm., expanded, 25–35 mm.; girth about 40 mm.

Callosamia angulifera Walker.—Color generally yellowish or yellowish brown, darker brown on the middle of the back and around the margins of spiracles, usually a darker color pattern on wings; dorsal aspect of thorax and abdomen with deep, wavy, transverse striations, fine indeterminate striations on face parts and appendages, the remainder of the surface practically smooth; dorsal cephalic margins of abdominal segments 5–7 never produced into flange-like plates; line between segment and conjunctiva on dorsal aspect elevated and corrugated; antennæ of male meet on meson and lie adjacent to each other for a distance nearly equal to their width, their length three times the width, antennæ of female separated to show first and second pairs of legs, their length three and one-third times width, ending just below first pair of legs; no eye-pieces visible; labrum variable, usually broadly truncate distally; maxillæ with mesal length greater than breadth at cephalic end; margin of the second pair of wings deeply bisinuate, a narrow portion produced below anal angle of first wing and extending less than half way across its caudal margin; first and second abdominal spiracles seldom partially covered by wings; spiracular openings with an elevated, rounded, smooth, lenticular margin, the lips of the openings rounded and pitted; tip of abdomen rounded. Length, abdomen retracted, 20–25 mm., expanded 25–30 mm.; girth, 40 mm.

Genus **Eupackardia** Cockerell.

This genus strongly resembles Callosamia, except for the points indicated in the key. The face parts are slightly elevated; antennæ pectinate throughout, the stem of the flagellum always elevated above the level of the pectinations and about one-third the total width; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture indicated by a slight furrow; maxillæ measured on the meson one-sixth the length of the wings; tarsi of the first pair of legs and tips of the second pair adjacent on the meson; caudal part of the mesonotum and metanotum depressed adjacent to the wings and strongly wrinkled, the wrinkles extending over the first two abdominal segments; wings with their distal margin always raised above the level of the dorsal surface of the body; first pair of wings with their anal angles rounded and opposite the cephalic margin of the fourth abdominal segment; second pair of wings scarcely visible opposite the second abdominal spiracle, but otherwise entirely visible around the first wing and extending below it on the ventral surface, reaching about half the distance along the caudal margin of the first wing; abdominal segments 8 to 10 tapering rapidly to form a cone-shaped piece; cremaster absent.

This genus includes a single species. *Eupackardia calleta* is reported from Arizona and Mexico. Its cocoon is very firm, flask-shaped, with loose fibers of silk forming a sort of valve across the open cephalic end. It is suspended from a twig by means of a very short band of silk which encircles the twig.

Eupackardia calleta Westwood.—Color generally dull black with a yellowish face-piece; exposed surface of thorax, face-pieces and appendages with fine indeterminate transverse striations, remainder of surface practically smooth; dorsal cephalic margin of abdominal segments 5 to 7 never produced into flange-like plates; never with an elevated line between the segment and the transverse conjunctiva; antennæ of female extends to tips of first pair of legs and length is four times width, in the male they reach to tips of second pair and length is three and one-half times width; glazed eye-pieces visible; labrum variable, generally elevated, pentagonal or shield shaped; maxillae with mesal length and breadth at cephalic end approximately equal; margin of second wing slightly sinuate, produced below anal of front wing to caudal margin of fourth abdominal segment and more than half way across caudal margin of first wing; first and second abdominal spiracles partially covered by the wings; spiracular openings located at the bottom of lenticular depressions, margins of the openings felted; tip of abdomen rounded with ten or more short, rigid spines less than one millimeter long, forming a circular group. Length, abdomen retracted, 25–30 mm., expanded 35–40 mm.; girth about 50 mm.

Genus **Rothschildia** Grote.

Exposed surface of thorax and abdomen sparsely covered with fine setæ; face-parts slightly elevated; antennæ pectinate throughout, tapering gradually to a point at the distal end, length and width varying with the sexes and reaching more than half way between the tips of first and second pairs of legs; antennæ of male elevated, with a depression on each side the stem of the flagellum; antennæ of female with the stem of the flagellum raised above the level of the pectinations; invaginations for the anterior arms of the tentorium indistinct; eye-pieces both visible; clypeo-labral suture generally distinct; maxillæ, measured on meson, about one-fifth the length of wings, triangular in outline, its mesal length greater than the width at proximal end; tarsi of the first pair and tips of the second pair of legs adjacent on the meson; metanotum wrinkled at base of wings but not always depressed; wings with their distal margins raised above the dorsal surface; first wing with its angle on cephalic margin of fourth abdominal segment; second wing visible along dorsal margin of first wing, its margin entire and produced below the anal angle of first wing to the caudal margin of the fourth abdominal segment, extending more than half way across margin of first wing; spiracular line curves ventrad; cremaster wanting; abdominal segments 8–10 bluntly cone-shaped, the caudal end with a band of coarse setæ about one millimeter long, either erect or closely appressed to the body.

This genus consists of two species found in Arizona and southward into Mexico. The cocoons are very firm, those of *R. orizaba* being about two inches long, three-fourths of an inch wide, rather ovoid in shape, usually slightly narrowed and rounded at the ends, while those of *R. jorulla* are vase-shaped, about of the same dimensions with a well defined opening laterally at the cephalic end, showing the valvular arrangement of loose fibers. Both species have very light grayish tan cocoons, those of *R. jorulla* being suspended by a band of silk at the cephalic end. The pupæ of the two species can be separated as follows:

A. Median thoracic line distinct on all segments; caudal part of mesonotum and metanotum depressed at base of wings; distal margin of wings strongly elevated above the dorsal surface of body; setæ on metathorax and first four abdominal segments sparsely distributed, inconspicuous. *orizaba.*

AA. Median thoracic line never distinct on metathorax and often indistinct on mesothorax; caudal part of mesonotum and metanotum not depressed at base of wings; distal margin of wings only slightly elevated above the dorsal surface of the body; setæ numerous on metathorax and first four abdominal segments, conspicuous, at least a millimeter in length. *jorulla.*

Rothschildia orizaba Westwood.—Color generally black with light brown transverse conjunctiva, sometimes abdominal segments 5–10 or 8–10 are light in color; exposed parts of thorax and abdomen sparsely covered with reddish setæ, less than a millimeter long and almost invisible; thoracic segments, face parts and appendages with indeterminate, transverse striations, abdominal segments smooth; antennæ of male with length two and three-fourths times breadth, female with length four times the breadth; face parts curving sharply to the level of the labrum and maxillæ; labrum variable, width about twice length, usually five-sided and slightly elevated above maxillæ; maxillæ, measured on meson, one-sixth the length of wings; median line distinct on all thoracic segments; mesothorax tuberculate at base of wings; caudal part of mesonotum and metanotum strongly depressed adjacent to wings; the distal margin of first wing always considerably elevated above the dorsal surface of body; mesothoracic spiracles slit-like; abdominal spiracles free, second abdominal spiracle one-half the width of its margin away from the wing; caudal end of abdomen with band of stiff, straight setæ, always erect. Length, abdomen retracted, 23–27 mm., expanded, 30–37 mm.; girth about 50 mm.

Rothschildia jorulla Westwood.—Color usually reddish brown; exposed surface of thorax, and usually the face parts, with fine, indeterminate, transverse striations, deeper on the prothorax; abdominal segments 1–4 with minute tubercles, remainder of body surface practically smooth; exposed surface of thorax and abdomen with conspicuous, coarse reddish setæ, most numerous on the first four abdominal segments and sparsely distributed over the remainder; antennæ in both sexes separated by the legs and extending more than half way between the tips of the first and second pairs of legs, length in the male three times the breadth, in the female almost four times the breadth; face parts convex, mostly in the clypeal region; labrum variable, always broader than long and generally with a rounded median lobe; maxillæ, measured on meson, one-sixth the length of wings; median thoracic line distinct on prothorax and part of mesothorax; mesothorax roughened and metanotum longitudinally wrinkled at base of wings, but never noticeably depressed; distal margin of first wing only slightly elevated above dorsal surface of body; abdominal spiracles usually free, second abdominal spiracle adjacent to the wings; caudal end of abdomen with a narrow, transverse band of setæ, sometimes extending on dorsal surface of tenth abdominal segment, either erect or closely appressed to body. Length, retracted, 25–28 mm.; girth about 45 mm.

Genus **Samia** Hübner.

Body cylindrical; face parts slightly elevated; antennæ with the stem of the flagellum raised above the level of the pectinations, in the female the antenna is pectinate throughout, not prominently elevated above the surface of the wings, and tapering gradually to a pointed tip at the distal end, in the male strongly elevated above the surface of the wings, the sides approximately parallel for the greater part of their length and tapering gradually to a blunt, rounded tip at the distal end, the stem of the flagellum often extending beyond the pectinations; a portion of the glazed eye-piece always visible in the female, sometimes in the male; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture usually distinct; labrum with width always much greater than length; maxillæ, measured on meson, never less than one-fifth the length of wings, triangular in outline, and usually smooth in comparison with the other appendages, occupying a more or less sunken area between the elevated face parts and the first pair of legs; tarsi of the first pair of legs and tips of the second pair of legs adjacent on the meson; median line always very distinct on the prothorax, weak on the mesothorax and sometimes slightly indicated on the metathorax; caudal portion of mesonotum and the metanotum depressed adjacent to the wings; wings with their distal margins always strongly raised above the dorsal surface of the body; first pair of wings with their anal angles rounded and opposite the cephalic margin of the fourth abdominal segment; second pair of wings visible along entire margin of first wing, but usually almost concealed by the first wing on the third abdominal segment and produced around the anal angle of first wing to the caudal margin of the fourth abdominal segment; abdominal segments usually with three rows of tubercle scars on each side the meson, one row situated laterad of the dorsal medial line about one-fourth the distance between the medial line and the spiracular line, the second row on the dorsum about half way between the first row and the spiracular line, the third row on the ventral surface, not quite half way between the spiracular line and the proleg scars; abdominal segments 8–10 tapering rapidly to form a cone.

The genus *Samia* is found in nearly all parts of North America. There are four recognized species in this genus, *S. cecropia*, reported from the entire region east of the Rocky Mountains, *S. gloveri*, from the Rocky Mountain region and Arizona, S. columbia, from the Northern Atlantic States, and *S. californica*, from the Pacific States. The cocoons are always fastened by one side to a twig with fibers of silk; the general shape is oval. Cecropia cocoons are large, the largest found in North America, usually at least three inches long with two distinct layers of silk. There are many different shapes and at least two distinct types of cocoons, those with a very loose, soft outer layer giving the cocoon a "baggy" appearance and those firmer on the outside which are seldom more than an inch in width, often only three-fourths, while the "baggy "ones usually reach a width of two inches or even more. No satisfactory explanation has been given for this variation. The cocoons of the other species are similar to those of *S. cecropia* but smaller and usually firm. The cocoon of *S. gloveri* may usually be recognized by its external coating of white silk, which is spun first by the larva. The other species usually have grayish-tan or brown cocoons. The pupæ of these species may be separated by the following table:

A. Dorsum of abdominal segments finely deeply rugose, glossy, somewhat resembling velvet; color usually very dark brown or black.
    B. Ventral row of tubercle scars always present and conspicuous, usually smooth and shining; tubercle scars on the metathorax and first abdominal segment very prominent and often red in color. *gloveri.*
    BB. Ventral row of tubercle scars never present; tubercle scars on the metathorax and first abdominal segment small and inconspicuous and never red in color. *californica.*
AA. Dorsum of abdominal segments finely rugose, but not deep enough to give the dull surface a velvety appearance; color usually yellowish or chestnut brown, rarely black.
    B. Maxillae one-fifth the length of the wings; length normally over one inch. *cecropia.*
    BB. Maxillae one-fourth the length of the wings; length not over one inch; tubercle scars of the metathorax and first abdominal segments usually prominent, often elevated and tipped with red. *columbia.*

Samia californica Grote.—Color variable, typical specimens black, the caudal abdominal segments often light brown or yellowish and occasional specimens almost entirely yellowish brown; face parts, appendages and exposed surface of the thorax with fine, wavy, indeterminate transverse striations; dorsal abdominal segments 1–8 finely, deeply rugose resembling velvet, glossy in appearance, remainder of surface practically smooth; antennæ of male with the stem of the flagellum about one-fourth the total width of the antenna and with the tips sometimes extending beyond the pectinations; the length of the antenna a little more than twice the width and almost reaching the tips of the second pair of legs, the distal half of each antenna occasionally lying adjacent on the meson; antennæ of female with the stem of the flagellum one-third or more the total width of the antenna, ending opposite the tips of the first pair of legs and slightly shorter in some abnormal specimens, length a little more than three times width; clypeo-labral suture usually distinct; the clypeus not prominently convex cephalad of the labrum; labrum variable, concave on its proximal margin, broadly rounded or slightly pointed at distal end, the width at least twice the length; maxillæ, measured on meson, about one-fourth the length of wings, the mesal length usually greater than the greatest width; third pair of legs often showing between the wings; mesothorax with the alar area slightly polished, never showing a distinct tubercle or tubercle scar; metathorax without distinct tubercles; second pair of wings visible around entire dorsal margin of first pair of wings, and seldom concealed by them on the third abdominal segment, produced below the anal angles of first pair of wings to the caudal margin of the fourth abdominal segment; spiracles usually free, the first and second seldom partially covered by the wings; abdominal segments with the two dorsal rows of tubercle scars generally distinct, but never having the row on the ventral surface between the spiracular line and the proleg scars; abdominal segments 5–7 with their dorsal cephalic margins produced into narrow flange-like plates extending laterad to the spiracular line, with a distinct notch at meson and the median line indicated by oblique striations, also with a raised, wavy line between the segment and the transverse conjunctiva; abdominal segments 8–10 with the caudal end produced into a narrow blunt tip; the scars of the anal prolegs never distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, 30–35 mm., expanded, 40–45 mm.; girth about 50 mm.

Samia cecropia Linnaeus.—(Figs. 8, 9, 10). Color variable, usually chestnut brown with black on thorax and appendages, sometimes yellowish brown, but never entirely black; face parts, appendages, and exposed surface of thorax with fine, indeterminate, transverse striations, dorsal abdominal segments 1–8 finely rugose, but dull in appearance, not resembling velvet, remainder of surface practically smooth; antennæ of male with the stem of the flagellum about one-fourth the total width of the antenna and always extending beyond the pectinations, the length of the antenna about two and one-half times the width and almost reaching the tips of the second pair of legs; antennæ of female with the stem of the flagellum at least one-third the total width, the length of the antenna about three and one-half times the width and never extending as far as the tips of the first pair of legs; clypeo-labral suture generally distinct, clypeus prominently convex cephalad of the labrum; labrum concave on its proximal margin, broadly rounded at distal end, the width more than twice the length; maxillæ, measured on meson, about one-fifth the length of the wings, length and width approximately equal; third pair of legs very rarely showing between the wings; mesothorax with the alar area polished, usually showing a distinct tubercle or tubercle scar; metathorax without distinct tubercles; second pair of wings usually visible around entire dorsal margin of first wing, often almost concealed by first wing on the third abdominal segment and produced below the anal angle of first wing to the caudal margin of the fourth abdominal segment; spiracles usually free, the first and second sometimes partially concealed by the wings; abdominal segments with the three rows of tubercle scars distinct; abdominal segments 5–7 with their dorsal cephalic margins very rarely produced into flange-like plates and these scarcely visible in lateral view, and elevated, longitudinally striate, wavy line between the segment and the transverse conjunctiva; abdominal segments 8–10 with the caudal end seldom produced into a narrow, blunt tip; in ventral view the scars of the anal prolegs usually distinct on each side of the anal plate; cremaster absent. Length, abdomen retracted, 32–35 mm., expanded, 40–45 mm.; girth about 55 mm.

Samia columbia Smith.—Color usually dark brown to blackish; face parts slightly elevated; face parts, exposed surface of thorax and dorsal surface of abdomen with fine, determinate, transverse striations, specially marked on the mesothorax, metathorax and face pieces; antennæ of male with the stem of the flagellum about one-third the total width of the antenna, and not extending beyond the pectinations, the length of the antenna about two and three-quarters times the width, ending opposite the tips of the first pair of legs; clypeo-labral suture usually distinct; clypeal region strongly elevated, mound-like, above the labrum; labrum variable, its proximal margin concave, width at least twice length, the distal margin broadly rounded; maxillæ, measured on meson, one-fourth the length of the wings, its mesal length usually greater than greatest width, the surface polished; third pair of legs very seldom visible between the wings; mesothorax with the alar area longitudinally rugose throughout, appearing somewhat polished to the unaided eye; metathorax with a prominent tubercle on each side the meson, a smaller one near each lateral margin, both tubercles reddish at tip; a similar pair usually present each side the meson on the first abdominal segment; second pair of wings not visible around entire dorsal margin of front wing being covered by the first pair of wings between the first and third abdominal spiracles; abdominal segments with the three rows of tubercle scars present and conspicuous; abdominal segments 5–7 sometimes with indications of a flange-like plate notched at the meson but never extending as far laterad as the spiracular line, the caudal margin scarcely elevated adjacent to the conjunctiva; spiracle of the third abdominal segment and sometimes of the second partially covered by the wings; tip of abdomen usually slightly produced into a blunt tip; the scars of the anal prolegs seldom distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, 23–26 mm., expanded, 26–30 mm.; girth about 35 mm. Described from male specimens only.

Samia gloveri Strecker.—Color variable, usually dark brown to black with traces of yellowish brown; face parts, appendages and exposed surface of thorax with fine, indeterminate transverse striations, abdominal segments finely, deeply rugose, usually velvety in appearance; antennæ of male with the stem of the flagellum about one-fourth the total width of the antenna, the stem of the flagellum projecting slightly beyond the pectinations, and extending almost to the tips of the second pair of legs, the length about two and three-quarters times the breadth; antennæ of female with the stem of the flagellum about one-third the total width of the antenna, extending to the tips of the first pair of legs, the length four times the width; clypeus not prominently convex above the labrum; labrum variable, seldom concave at proximal end and, if concave, only slightly so, width greater than length and broadly curved at distal end; maxillæ, measured on meson, between one-fourth and one-fifth the length of wings, seldom smoother than the other appendages, the median length and greatest width approximately equal; mesothoracic spiracles partially covered by antennæ; mesothorax with alar area polished; second pair of wings never visible around entire dorsal margin of the first pair of wings, but concealed by the first pair of wings between the first and third abdominal spiracles; metathorax without prominent tubercles, a prominent, usually reddish tubercle scar on each side the meson, and a small tubercle near each lateral margin of the metathorax; abdomen with three rows of tubercle scars, conspicuous and polished; cephalic margins of abdominal segments 5–7 with indications of a flange-like plate near the meson, the edges of the segment adjoining the transverse conjunctiva longitudinally ridged but scarcely elevated; first and second abdominal spiracles partially concealed by the wings; abdominal segments 8–10 with the caudal end produced into a narrow blunt tip, in ventral view the scars of the anal prolegs distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, 30–35 mm., expanded, 35–40 mm.; girth, 45–50 mm.

Genus **Philosamia** Grote.

Face parts slightly elevated; antennæ pectinate throughout, tapering gradually to a point at the distal end, the stem of the flagellum distinctly raised above the level of the pectinations and nearly one-third the total width of the antennæ, similar in the sexes; glazed eye-pieces visible in both sexes; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture indistinct; maxillæ, measured on the meson, about one-third the length of the wings; tips of first and second pairs of legs adjacent on the meson; median thoracic line distinct on all segments; caudal part of mesonotum and metanotum depressed adjacent to wings; wings with their distal margin raised above the dorsal surface of the body; first wing with its anal angle broadly rounded, opposite the second abdominal spiracle; second wing generally visible along the entire dorsal margin of first wing, its margin wavy, produced into a prominent anal angle reaching the caudal margin of the fourth abdominal segment; abdominal segments 8–10 tapering rapidly to form a blunt or truncate cone; cremaster absent.

This genus contains a single species, *Philosamia walkeri*, which is a native of China and was introduced into America from Europe. At first it was confined to the Atlantic Coast States, but is gradually spreading westward. The cocoons are on an average two inches long, half an inch wide and pointed at the caudal end. The cephalic end is open with a valvular arrangement of loose fibers of silk. The cocoons are encased in a leaf and suspended from the twigs by a band of silk spun over the petiole of the leaf holding it to the stem. The cocoons are pale gray or grayish tan in color and closely resemble the cocoons of *C. promethea*.

Philosamia walkeri Felder.—(Fig. 14). Color generally yellowish brown, darker on wings and dorsum; exposed surface of thorax and abdomen with fine, indeterminate, transverse striations; antennæ reaching half way between the tips of the first and second pair of legs; labrum short and broad, its width usually six times the length; maxillæ triangular in outline, lateral margin with the proximal two-thirds concave; abdominal segments with a heavy, raised, slightly wavy line on the dorsal and lateral aspects of the caudal margin, extending ventrad to the proleg scars, a similar line along the cephalic margin ending opposite the spiracles; two dorsal rows of tubercle scars as in *Samia*. Length, abdomen retracted, from 20–30 mm., expanded, 25–35 mm.; girth about 40 mm.

EXPLANATION OF PLATES.

Plate V.

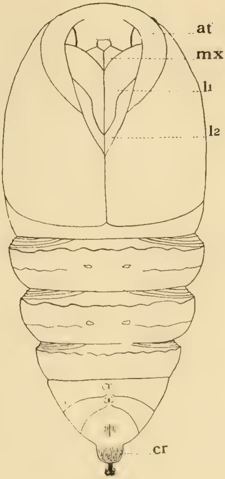
Fig. 1. Ventral view of a pupa of Automeris io.
Fig. 2. Lateral view of a pupa of Automeris io.
Fig. 3. Ventral view of a pupa of Adelocephala bicolor.
Fig. 4. Ventral view of a pupa of Hemileuca maia.
Fig. 5. Dorsal view of a pupa of Hemileuca maia.
Fig. 6. Ventral view of a pupa of Citheronia regalis.
Fig. 7. Lateral view of a pupa of Citheronia regalis.

Plate VI.

Fig. 8. Ventral view of a pupa of Samia cecropia.
Fig. 9. Dorsal view of a pupa of Samia cecropia.
Fig. 10. Lateral view of a pupa of Samia cecropia.
Fig. 11. Lateral view of a pupa of Telea polyphemus.
Fig. 12. Wing sclerites of Telea polyphemus showing spines.
Fig. 13. Ventral view of a pupa of Tela polyphemus.
Fig. 14. Ventral view of a pupa of Philosamia walkeri.

ABBREVIATIONS.

al—alar area
ao—anal orifice.
at—antenna.
ax—axillary sclerite.
cl—clypeus.
cm—cephalic margin.
cr—cremaster.
dts—dorsal tubercle scar.
dlts—dorso-lateral tubercle scar.
ge—glazed eye.
go—genital orifice.
l—leg.
lb—labrum.
md—mandible.
mn—mesonotum.
ms—mesothorax.
mt—metathorax.
mx—maxillæ.
ps—proleg scar.
pt—prothorax.
s—segment.
se—sculptured eye.
sp—spiracle.
spi—spine.
t—tubercle.
tc—transverse conjunctiva.
vts—ventral tubercle scar.
w—wing.
wt—wing tubercle.



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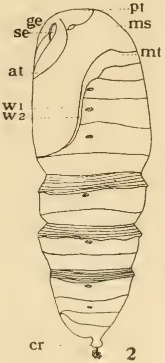

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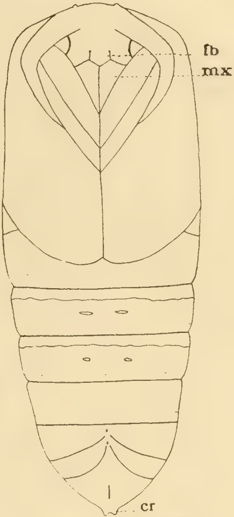

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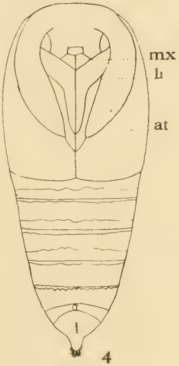

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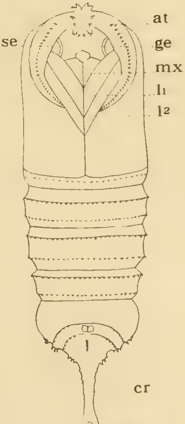

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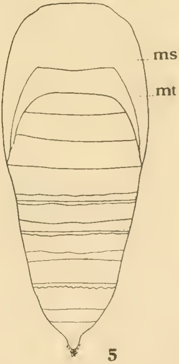

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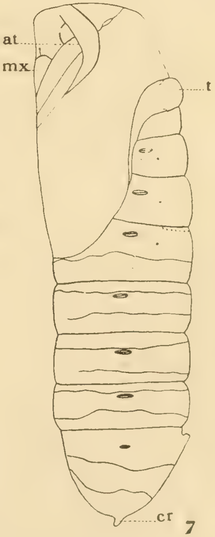

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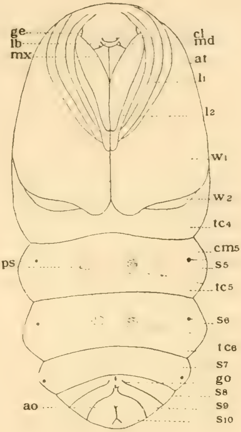

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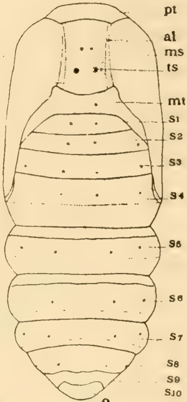

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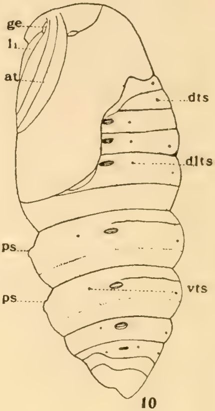

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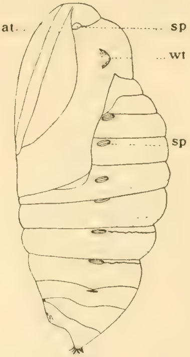

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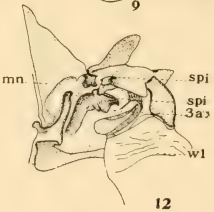

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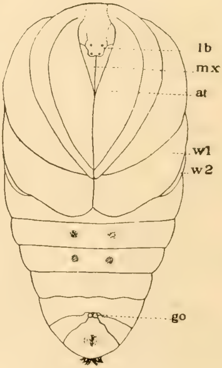

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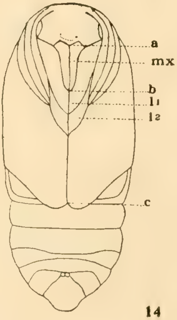

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Edna Mosher

CONTRIBUTION TO THE BIOLOGY OF CERTAIN AQUATIC LEPIDOPTERA.*

PAUL S. WELCH.

Insects of the order Lepidoptera are so pre-eminently terrestrial in organization and habit that the existence of aquatic species is not commonly known, even among biologists. Information concerning American forms which inhabit the water is meager and only a few of their remarkable adaptations have been described. Klapálek and Grünberg ('09, pp. 96–159) discuss sixty species and varieties, which they consider as aquatic, from the fresh waters of Germany and there is reason to believe that ultimately the American aquatic species will be found to exceed that number. During the summers of 1911–15 the writer made some studies of the Lepidoptera of Northern Michigan in connection with which special attention was given to the aquatic group. The data, which form the basis of this paper, were secured in the immediate vicinity of Douglas Lake, in the extreme northern part of the Southern Peninsula. Certain portions of the margins of this lake are rich in aquatic vegetation and afford good breeding grounds for a considerable variety of aquatic animal life. Adults of five species of the genus *Nymphula* (Welch, '15, p. 118) were found in some abundance about the protected bays and beach pools. This genus is unique in being one of the very few groups of Lepidoptera which include species having aquatic stages in the life history. Of the species of *Nymphula* known to occur in North America, six are aquatic in some or all of the immature stages. The larvæ of several other species are not known, but it is probable that they, too, will be found to be aquatic.

In the past, generic divisions have been made in the group of species now included under *Nymphula*, based mainly on certain structural characters of the larvæ. Those species having tracheal gills in the larval stage were assigned to a separate genus, *Paraponyx*, a name still retained by some foreign workers. In this paper, the writer follows the present American practice of including the group assigned to *Paraponyx*, together with others, under the genus *Nymphula*, even though two distinct types of larvæ are thus involved.

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*Contribution from the University of Michigan Biological Station, No. 33, and the Department of Entomology, Kansas State Agricultural College, No. 16.

Nymphula maculalis Clemens.

Nymphula maculalis occurred in some abundance in the immediate vicinity of the yellow water-lily beds and the writer was able to observe the development of this species, both in the field and in the aquaria, from the egg to the adult several times during the five successive summers, thus establishing the identity of the following described immature stages.

THE EGG (Pl. VII, Fig. 5).

The eggs were first described by Forbes ('10, p. 221) as follows: "*Eggs* were laid in captivity, but not in a regular egg-mass. They were oval and flattened, .65 by .5 mm., and had no decided longitudinal ridge. Duration of stage about ten days." This meager description, which seems to be the only one that has been published, contains no hint of the very interesting method of deposition under natural conditions. The writer made a careful study of this part of the life history and the results will be given in some detail.

Place and Method of Deposition.—Eggs were found only on the yellow water-lily, *Nymphæa americana* (Provancher) Miller & Standley. Other aquatic and semi-aquatic plants growing in the vicinity of the yellow water-lily beds were examined carefully but no eggs were found on them. They are laid on the lower side of the floating water-lily leaf and are thus constantly submerged.

Oviposition is associated in a very interesting and unique way with the deposition of the eggs of another aquatic insect. During the past five summers, the writer found about one hundred egg masses of *N. maculalis* in the field and, without exception, all were deposited in the manner to be described. A species of chrysomelid beetle (*Donacia* sp.), which occurs in considerable abundance about the water-lily beds of Douglas Lake, deposits its eggs on the lower surface of the leaves of the yellow water-lily in a very characteristic way. The female cuts a circular hole, 4–6 mm. in diameter, through the leaf and then, by means of a long ovipositor, lays two concentric rows of white, elliptical eggs around the margin on the lower surface. These concentric rows are very rarely complete, so that there may be two or more groups of eggs around the hole with varying intervening spaces. The interesting thing is the fact that the female of *N. maculalis* uses the holes made by *Donacia* sp. for the deposition of her eggs, thus taking advantage of the work of the female beetle. The eggs of *N. maculalis* are laid in concentric rows on the lower surface of the leaf, about the circular hole and occupy space not utilized by the eggs of *Donacia.* Recently deposited eggs of both beetle and moth were frequently found about the same hole, showing that oviposition by the former is sometimes followed shortly by egg deposition by the latter. Recently deposited eggs of *N. maculalis* were occasionally found about the egg holes of *Donacia* from which the eggs of the latter had disappeared. The number of concentric rows of *N. maculalis* eggs varies slightly but in the larger egg masses there are six. The eggs are so placed that the long axes are radial with reference to the hole about which they occur. The number of eggs in a cluster varies rather widely. Frequently, the size of the cluster is determined by the amount of space unoccupied by the eggs of *Donacia.* In a few instances, the egg mass completely surrounded a *Donacia* egg hole, eggs of the latter being absent. An examination of a large quantity of these egg masses showed that the number of eggs in each varied from twenty-two to two hundred eighty.

The act of oviposition was not observed and exact data on this activity are lacking. However, the necessities make it possible to draw tentative conclusions. The female of *N. maculalis* has no means of making a hole through the leaf and, since the eggs are laid in the above-described manner, she uses the holes provided by some other agency. Even though the writer has failed, in the collections of five summers, to find a single egg mass in the field which was not associated with the egg holes of *Donacia*, it seems improbable that the female *N. maculalis* is restricted to them for egg deposition. In the region examined, *Donacia* is the only animal which makes a small, symmetrical hole through the leaf, a fact which may account for the constant relation between the egg-laying habits of the two species. Similar holes of different origin, if present, might also be used. Since in most of the egg masses there are six concentric rows so arranged that the row most remote from the margin of the hole is four or five millimeters away, the question arises as to the means whereby the female is able to deposit eggs at such a distance from the edge of the hole. An examination of the females of *N. maculalis* shows that the terminal abdominal segment is elongated, cone-shaped, movable, bent ventrad, and bears a long, protrusible ovipositor. Thus it is possible for the female to deposit eggs from the top of the leaf by clinging at the margin of the hole and extending the ovipositor around the edge to the lower surface of the leaf. It also appears that the sixth concentric row of eggs in an egg mass represents the limit of extension of the abdomen and ovipositor.

A number of experiments were performed in order to secure further data on egg deposition. In each experiment, a single female, fresh in appearance and bearing evidences of recent emergence from the pupa, was captured in the field, brought to the laboratory, and placed in a well-lighted aquarium in which a yellow water-lily leaf, bearing no *Nymphula* eggs but having one or more *Donacia* egg holes, was floated on water. Frequent examinations were made of each aquarium during the day and the early part of the night. The results, based upon a number of such experiments, are as follows:

(1) Deposition of eggs invariably occurred at night.
(2) Eggs were deposited only about the *Donacia* egg holes.
(3) A female may deposit eggs for five successive nights before oviposition ceases.
(4) *Donacia* egg holes, devoid of *Donacia* eggs, were sometimes completely surrounded by six concentric rows of eggs of *N. maculalis*.
(5) An egg mass, deposited during one night, was sometimes covered, in part, by a second layer of eggs deposited on a succeeding night. Apparently, the deposition of one egg mass on another was an abnormal action, due, possibly, to laboratory conditions, although, aside from the limited space, the conditions in the aquarium resembled those of the natural environment as nearly as possible. Egg masses collected in the field invariably showed but a single layer. It is conceivable that such a reaction might result from the total reduction of available space about the *Donacia* egg holes, but experiments showed that it occurred when the same leaf contained holes which afforded abundant space.
(6) A single female usually utilized several *Donacia* egg holes before the egg laying period ended.
(7) The maximum number of eggs laid by a single female was 617.

The method of egg deposition in the absence of *Donacia* egg holes was of interest in this connection. Fresh, vigorous females, captured in the field, were placed in aquaria under conditions simulating the natural ones as nearly as possible. Each aquarium contained yellow water-lily leaves representing one of the following conditions: (1) entire leaves containing no *Donacia* egg holes; (2) leaves containing artificial holes, varying from narrow slits to circular holes, all of various dimensions; (3) pieces of leaves containing no holes and having smooth-cut edges; and (4) ragged leaves and fragments of leaves with very irregular edges but no holes of any sort.

The results of these experiments were as follows:

(1) Most of the females tested with entire, unpunctured leaves delayed oviposition until the second or third night and then laid diminutive egg masses on the lower surface of the leaf near the margin, particularly in the region of the leaf sinus.

(2) Egg masses were deposited around artificial incisions and punctures of various kinds and shapes.

(3) Apparently, the dimensions of artificial punctures and incisions played little or no part in determining the location of egg masses.

(4) In the absence of leaf punctures, egg masses were deposited near the edges of smooth-cut portions of leaves, on the lower surface; also about the irregular edges of ragged and mutilated leaves.

It is evident from field observations and the above-described experiments that the female of *N. maculalis* has a distinct preference for the egg holes of *Donacia* in oviposition and that when present they are constantly utilized. However, in spite of the fact that, in the Douglas Lake region, the eggs are normally and constantly placed as above described, it is evident from the experiments that the dependence upon the presence of *Donacia* egg holes is not absolute and it seems fair to assume that in case *N. maculalis* occurs in a locality where *Donacia* egg holes or similar leaf punctures are absent, egg masses would be deposited about the leaf margins of the food plant. Observations on the egg-laying habits of *N. maculalis* in other parts of the continent would be of interest in this connection. This moth is widely distributed, having been reported from localities ranging from the Gulf States to Central Canada. Species of *Donacia* are said to occur in all parts of the United States and Canada and, although not all of them lay their eggs around circular holes in water-lily leaves, it appears that at least one of the rather widely distributed species does have this habit. The extent of this egg-laying interrelation of the two groups of insects is a problem for the future.

Description.—The eggs are elliptical, smooth, slightly compressed, and constant in size. When first hatched, the maximum dimensions are 0.396 mm. and 0.549 mm. The development of the egg is accompanied by an increase in size so that just before hatching the dimensions are 0.450 mm. and 0.648 mm. Of the considerable number of measurements made, none varied more than 0.03 mm. and even this variation was exceptional. It will be noticed that measurements of the egg made previous to the time of hatching agree quite closely with those reported by Forbes ('10, p. 221). Apparently his measurements were made on eggs which were well advanced in development.

Development.—The egg period was found to be about eleven days, a result which agrees closely with that reported by Forbes. When first laid, the eggs are yellowish, having about the same color as the lower surface of the yellow water-lily leaf. They are also slightly translucent. As development goes on they become darker and proportionately more conspicuous on the leaf. During the first 2–4 days following oviposition, little if any change is apparent but subsequently internal differentiation becomes noticeable. The eggs develop uniformly and usually after a lapse of 3–5 days each begins to show a dark band within, shaped somewhat like the letter J. The position of this dark band is constant, the more curved end being in that extremity of the egg remote from the margin of the hole in the leaf. This band gradually becomes more conspicuous, ultimately revealing itself as the developing body of the larva. The triangular, chitinized pieces of the epicranium begin to appear at the end of the fifth day and it was noted that they develop in that end of the dark band nearest the margin of the leaf puncture, showing that there is a definite orientation of the egg and that the head of the larva develops at the less curved end of the band. At the close of the eighth day, the larva is quite distinct and occupies practically all of the space within the egg. At the end of about ten days, the egg has lost all of the original yellow appearance and the shell has become transparent. The tiny caterpillar can be easily examined and it begins to show movements within the egg. The primary regions of the body are now distinct (Fig. 4), the epicranium and the tips of the mouth parts are dark brown, the fronto-clypeal and the occipital regions are light yellow in appearance, and the chitinized, dark brown prothoracic shield and the dark bands in the regions of the intersegmental grooves are distinctly visible through the egg shell. In the eggs studied in this connection, the dark color appeared first in the ocelli and on the dorsal margins of the intersegmental grooves, later in the head and prothoracic shield. The larva is doubled upon itself with the caudal end extending around and beyond the head.

Hatching.—In almost every case, the entire egg mass hatched at about the same time. Occasionally, a few eggs lagged behind but they hatched not later than five hours after the main group of caterpillars had emerged. The first observed manifestations of the hatching process were motions of the larva within the egg, consisting of a series of body contractions and expansions combined with movements of the head. The mandibles were also in active motion. Apparently, the combined action of the mandibles and the body movements were responsible for the breaking of the egg shell. In the egg masses under observation, the movements of the larvæ preliminary to hatching began from four to six hours before the final escape. The larva emerged from one end of the egg, escaped quickly, and assumed an active habit. In egg masses deposited under natural conditions, the number of imperfect eggs was very small, not exceeding three per cent.

The dates of collection of egg masses varied from July 10 to August 20. Possibly, differences of seasons have some influence on the egg-laying period since in 1913 numerous egg masses were found as late as August 20, while during the preceding summer none were found later than July 30.

THE LARVA (Pl. VII, Figs. 1–3).

First Instar.—The first instar has been briefly described by Forbes ('10, p. 221) as follows: "*Stage I* (. . . . . . .) Slightly larger than N. gyralis? described below, with proportionately much larger anal setæ, without trace of gills. Head nearly .3 mm.; length of large anal setæ 1 mm." A careful study of this instar has made it possible to extend the description.

The larva, in this instar (Fig. 1), is light yellowish brown in general appearance. The body is elongate, subcylindrical, and tapers very slightly caudad. Body length of newly hatched larvæ varied from 1.26 to 1.5 mm. The maximum diameter is in the region of the prothorax where it is about 0.32 mm. The main divisions of the body and the intersegmental grooves are distinctly marked. Duration of first instar in specimens reared in aquaria, about 7 days.

Head approximately 0.3 mm. in width, smooth, shining, and dark yellowish brown. Epicranial suture distinct. Front, clypeus and labrum light yellow. Labrum emarginate, setose.

Mandibles toothed, tips blackish. Labial palpi distinct, penultimate segment truncate-conic, ultimate segment smaller and cylindrical, not more than twice as long as thick, terminating distad in three short, stout spines. Maxillary palpi minute and inconspicuous, terminating in three minute articles. Antennæ distinct, basal joint truncate-conic, second segment slender, cylindrical, about three times as long as thick; distal extremity with an apical seta nearly twice as long as segment bearing it, and four minute articles, one of which bears a short seta. Ocelli five, arranged in semicircle just caudad of base of each antenna; dark area in connection with each group. One pair of setæ on epicranium near mid-dorsal line; a similar pair near mesal margins of ocelli groups; two strong setæ on each lateral surface of head near ocelli.

Thoracic segments very finely granulose. Cervical shield broad, black in color, strongly chitinized, smooth, widest at mid-dorsal region; margins regular, anterior margin very slightly conate, posterior margin slightly convex; covers greater part of dorsal surface of prothorax. Meso- and metathorax without traces of black, not strongly chitinized; color uniformly yellowish. Legs similar in size and color, each ending in a single, strong curved claw. Each thoracic segment with three pairs of well-developed setæ on lateral and dorso-lateral surfaces.

Cephalic margin of abdominal segments I–VIII bordered with black; IX–X devoid of dark color. Dorsal surface of VII and VIII darker than other segments. Posterior segments becoming narrower; IX narrow. Prolegs on III–VI and X. One pair of somewhat conical, fleshy projections on lateral aspects of each segment; one short, ventral seta and a longer, dorsal seta, latter about 0.27 mm. long, on each projection. Segment IX with four pairs of well-developed setæ on dorsal and lateral surfaces. Segment X with a pair of short setæ and one pair of longer setæ on dorsal surface; three setæ, two short and one longer, on each lateral surface; two setæ on caudal margin; and two very long setæ, 1.06 mm. in length, extending from the latero-caudal angles of posterior margin.

Second Instar.—This instar, as such, has not been described. Forbes ('10, p. 221), in his account of the life history of this species, states that "stage II" was "not seen; and no sign of leaf-mining was noticed." The same writer describes "stage

III", using an interrogation mark to indicate uncertainty, as follows: "A transparent caterpillar, essentially like the full-grown ones. The maximum number of gill-filaments is two, and the anterior suprastigmatals and the last three pedals have but one. Length about 4 mm.; head .6 mm." The writer has reared larvæ through the early stages from eggs laid by females in the aquaria and observed no indication of an instar between the first and the one described below as the second, the latter corresponding rather closely to the description of Forbes for "*Stage III.* (?)".

A rather surprising change (Fig. 2) takes place at the first ecdysis. The general shape of the larva is not changed but new structures appear. Measurements show the body to be about 2.5 mm. long. It is almost transparent, and the color of the material in the digestive tract shows through the body-wall, giving combinations of yellow and green to the general color.

Head about 0.38 mm. wide, otherwise as in the first instar. Thorax with margins of cervical shield black, remainder translucent; prothorax with five pairs of well-developed setæ; mesothorax with one pair lateral, filamentous gills; length of each gill about equal to width of corresponding segment; metathorax with two lateral, filamentous gills on each side, both of similar length and resembling mesothoracic gills. Legs translucent. Meso- and metathorax devoid of dark color. Abdomen without dark markings; two lateral gill filaments on each side of all segments except last two, one filament with length about equal to width of corresponding segment, the other about one-fourth shorter; penultimate segment with one lateral, filamentous gill on each side, about as long as width of segment; ultimate segment devoid of gills. No gills on dorsal surface of body. Last two segments with several pairs of setæ, one pair of which is terminal in position, long, and stout. Otherwise similar to first instar.

The interesting part of the change from the first to the second instar is the initial appearance of the tracheal gills in the latter. In most of the specimens studied, the lateral gills were constant in all respects, but a few showed variation from the typical condition. One specimen showed a small, extra gill on the left side of the ventral surface of the second abdominal segment. Another specimen bore only one gill on the right side of abdominal segments II, III, IV, and the left side of abdominal segments II and VII.

Third Instar.—The conditions under which these larvæ must be reared make it very difficult to follow the ecdyses so that the exact number of instars can be determined. The following described instar is identified in this paper as the third since, in the examination of many specimens of different ages in the field and laboratory, no indication of an instar between it and the second could be found. Larval changes were also followed as accurately as possible in specimens reared from eggs and the same result was obtained. The writer believes that the results warrant the designation of this form of the caterpillar (Fig. 3) as the third instar.

Length, 4–5 mm. General color pale yellowish. Head about 0.44 mm. wide, otherwise very similar to second instar. Thorax with anterior margin of cervical shield dark, remainder translucent; five pairs of setæ on prothorax; mesothorax with one pair of lateral, filamentous gills and one pair of dorsal, filamentous gills; metathorax with three pairs of filamentous gills, one pair laterad, one pair dorsad, and another pair ventrad. First abdominal segment with three pairs of gills similar in shape and position to those of metathorax; segments II and III, with one pair of dorsal, two pairs of lateral, and one pair of ventral gills; abdominal segments IV and V with two pairs of lateral and one pair of dorsal gills; segments VI, VII, and VIII, with two pairs of lateral gills; segment IX with one pair of lateral gills; segment X devoid of gills; segments IX and X with several pairs of setæ, one of which is terminal in position and much longer than others.

It will be noticed that the above description agrees to some extent with that given by Forbes for "*Stage IV*", the chief difference being in the maximum number of gill filaments. Although the writer has never found an instar in which the maximum number of gill filaments was three, he is inclined to believe that the third instar of this paper is the same as "*Stage IV*" described by Forbes.

Later Instars.—Examination of a large series of caterpillars, varying from the third instar to the full-grown state, showed the existence of a number of types, based on gill characteristics, gradating from the former to the latter. Each successive type is characterized by increase over the preceding one in body size and in the number of gill filaments. Whether or not each type represents an instar has not been determined and the discussion of later instars will be left for a future paper. The full-grown larva has been studied by Forbes ('10, p. 221) and the specimens studied in this connection agree with his description in most regards, assuming that his table of gill numbers represents an average condition and not a constant one. The most striking change in the later larval instars is the remarkable increase in the number of gills. The maximum number of gills per segment increases from two in the second instar to as many as ten per segment in the full-grown larva. The total number of gills increases from twenty-two in the second instar to one hundred in the last one. The number of gill filaments per segment increases from four in the second instar to as many as forty-eight in the mature larva. The total number of gill filaments on the whole body increases from forty to over four hundred. Such a provision of tracheal gills would seem to be adequate for a wide range of aquatic conditions.

Activities of the Larva.

Locomotion.—The young larvæ are active from the moment of hatching, crawling restlessly about over the egg shells and the adjacent leaf surface. Locomotion on the water-lily leaves consists exclusively of crawling movements. In the younger instars, particularly in the first, this method of locomotion is slow, often appearing awkward and inefficient. Crawling, in the older instars, is more active and vigorous and, under normal conditions, constitutes a comparatively efficient form of locomotion. The efficiency of crawling as a method of locomotion depends upon the character of the supporting surface. On the yellow water-lily leaf, crawling is accomplished with some degree of ease, except when the leaf, bearing larvæ on the upper surface, is submerged, a condition which seems to require extra effort. Crawling on the glass surfaces of the aquaria is very slow and inefficient, consisting of little more than a mere clinging to the glass, and change of position is accomplished with difficulty. Other surfaces of a smooth, firm nature also afford difficulties in crawling.

At no time during the larval period did the writer observe any evidence of an ability to swim. In this connection, a number of experiments were tried with larvæ of all ages but results were always negative. Random, writhing movements were exhibited when larvæ were submerged apart from a supporting surface but such movements were ineffective so far as change of position was concerned. However, another form of locomotion will be described later in connection with the discussion of case-making which serves as a substitute for true swimming.

Case-making.—A very interesting phenomenon in connection with the life history of *N. maculalis* is the case-making activities of the larva. This habit is common to the genus *Nymphula*, both in foreign and native species. Of the latter, Packard ('84, p. 824) gave a brief account of case-making by what was apparently *N. icciusalis* Wlk. Hart ('95, pp. 167–172, 176–180) described it in *N.* (*Paraponyx*) *obscuralis* Grt. and *N.* (*Hydrocampa*) *obliteralis* Wlk. Forbes ('10, pp. 220–21) gave a brief description of case-making in *N. maculalis* Clem.

The observations of the writer confirm, in most respects, the brief description of Forbes on case-making in *N. maculalis*. However, a number of additional data have been secured and will be discussed in some detail. As mentioned above, the larvæ are active from the moment of hatching. They emerge from the eggs and wander about restlessly for a time before starting to feed. In some of the aquaria, this period of preliminary wandering lasted for two or three hours. In the laboratory, the young larvæ seemed to show a preference for the submerged lower side of the leaf on which they were reared. The young larva, under laboratory conditions, soon began to make an incision in the leaf which was extended in such a way that ultimately a portion of the leaf, oval or circular in form and about 2 mm. in maximum dimension, was cut out and drawn back on the lower surface of the yellow water-lily leaf so that the larva was enclosed. Sometimes the larva cuts out the upper surface of its compartment, thus making an independent case composed of two similar pieces of leaf tied together by silken threads.

As the larva increases in size, the cases are outgrown and new ones made. With the older larvæ, case-making is a simple and rather rapid process. In constructing a new case, the larva crawls to the lower surface of a leaf and usually begins work near the periphery so that the resulting piece is cut out of the edge. However, an occasional leaf is found in which the piece has been cut out near the midrib. Certain random, preliminary movements are often performed, consisting chiefly of an apparent testing of the lower epidermis with the mandibles, before the larva settles down to the work of removing the piece. It works by using most of the length of the body as a radius and bending the anterior region as the incision is extended. After the initial incision is made, the head is held into the cut and a little to one side, thus placing the cutting plane of the mandibles at approximately right angles to the surfaces of the leaf. One-third of the complete incision may be made without changing the position of the posterior part of the body. Occasionally, a larva takes advantage of the overlapping margins of contiguous leaves. Since such a space is usually filled with water, the larva crawls into it, begins work, and in due time cuts an elliptical piece from one or both of the leaves.

The older larvæ utilize the excised pieces in making cases in several ways:

(1) A single piece may be cut out and tied flatwise against the lower side of the leaf.
(2) Two similar pieces may be cut out, forming a lens-shaped case, which is then tied flatwise to the leaf, or else becomes independent.
(3) Several pieces may be cut out, tied together into a case, and attached to the lower surface of the leaf.
(4) Two pieces may be cut out, tied together flatwise, and then attached endwise to the leaf.

The majority of the cases are placed on the lower, submerged surfaces of the floating leaves. Occasionally, cases containing larvæ are found on the dry, upper surfaces, a fact which suggests the possibility that the larvæ are not entirely dependent upon respiration by tracheal gills. It is a common thing to find numerous cases of various sizes attached to both surfaces of the submerged leaves of *Nymphæa americana*. How these larvæ get on the submerged leaves is not definitely known but it is possible that some of them, by wave action or other mechanical means, are dislodged from the floating leaves and sink to the submerged leaves, or else to the bottom from whence they crawl up the petioles to the leaves. The presence of young larvæ in such situations is discussed later.

The chief functions of the case appear to be (1) protection, and (2) support in the water. The protective function plays an important part in the life of the larva. These caterpillars occur in an environment where predaceous enemies are common and obviously the case is a rather efficient protection. The larva shows a very distinct tendency to respond to slight mechanical stimuli by immediate retraction into the case, a reaction which probably plays an important part in escaping enemies. Under normal conditions, the larva is apparently very shy, never, according to the observations of the writer, emerging completely from the case except in connection with the construction of a new one. At times, the anterior two-thirds of the body is projected from the case but such periods of partial emergence are of short duration, except when engaged in a special form of locomotion to be described later. Larvæ, removed from their cases and placed in aquaria provided with yellow water-lily leaves, very soon begin the construction of a new case.

The second function of the case—that of support in the water—is vitally connected with an interesting form of locomotion. The specific gravity of the older larvæ is greater than that of water and, unless supported, they will sink. The leaf tissue of the yellow water-lily has a specific gravity distinctly less than that of water and the oblong pieces cut out by the larva in case-making are always buoyant enough to easily support it. Therefore, all detached cases float at the surface and no effort on the part of the larva is required to support itself in the medium. Where larvæ are numerous, individuals are often found crawling over the top of the water-lily leaf, carrying the cases with them. To accomplish this form of locomotion, the larva extends the anterior part of the body from the case, uses the true legs as locomotor organs, and holds the case with the prolegs. When detached cases are dropped in the water, the larva performs certain movements which result in a change of position in space. As mentioned before, no evidence of an ability to swim was observed when larvæ were isolated from their cases. However, they do possess a form of locomotion in water in conjunction with their cases. The anterior portion of the body is projected from the case into the water and vigorous, horizontal, side to side motions are executed which result in the propulsion of both larva and case. It does not constitute a very efficient form of locomotion but is effective enough to bring the larva in contact with other water-lily leaves. If the horizontal movements are equal on either side of the long axis of the body, the result is a backward movement approximately in a straight line. If, as is often the case, the strokes are stronger on one side than the other, the result is an irregular rotation.

The effect of case-making upon the food plant is frequently serious. Some of the yellow water-lily beds (*N. americana*) about Douglas Lake are heavily infested at times with the larvæ of *N. maculalis* and suffer greatly (Figs. 12–19). The total effect of the larvæ on the food plant includes the amount of plant tissue consumed as food and the plant tissue utilized in case construction. According to the observations of the writer, the plant suffers much more from the case-making than from the removal of tissue for food. Case construction results in a reduction of the leaf surface which may be extensive enough to leave only the midrib. The writer observed beds of *N. americana*, in August, which, as nearly as could be estimated, had lost 40 per cent. of the total leaf surface by the case-making activities of these larvæ.

Food.—Very young larvæ, reared in shallow aquaria, fed on the lower side of the yellow water-lily leaf, feeding and case-making being accomplished at the same time. The translucency of the body made it possible to observe the first occurrence of green plant tissue in the digestive tract. After the case was made, the tiny larva fed to some extent upon the tissue of the case. However, the normal field habits of the larva in the first instar were not determined. In rearing young larvæ in aquaria, some difficulty was experienced in securing the second instar and in preventing a very high mortality among those which hatched from egg masses. The following circumstantial evidence suggests that possibly the larvæ, after hatching, settle to the bottom and after one or two ecdyses, approach the surface of the water on the petioles of the water-lily:

(1) Recently hatched larvæ have a tendency, in the aquaria, to drop to the bottom and to wander about.
(2) The first and second instars were not found on the floating leaves of the yellow water-lily where the egg masses occurred.
(3) It was frequently observed that in water-lily beds in which the floating leaves had petioles two or more feet long, the *submerged* leaves bore young larvæ (third instar or a little later) while the floating leaves bore only the more advanced larvæ. Some of the submerged leaves had petioles only about one inch long, so that the leaf was practically on the bottom.
(4) Very rarely did pupæ occur on the submerged leaves.

Larvæ, hatching in very shallow aquaria, ate the yellow water-lily leaf tissue and some developed into the second instar, but it is possible that it was not the normal reaction and that the first instar may be passed on the bottom. In later instars, feeding was confined largely to adjacent leaf tissue not a part of the case itself. All excrement was voided outside of the case, thus providing for the cleanliness of the interior.

Forbes ('10, p. 220) states that in addition to *Nymphæa*, *Castalia* and *Brasenia* are used by *N. maculalis* in case-making and his description leads one to infer that all of these plants are used as food. The writer has found no evidence of feeding or case construction involving plants other than *N. americana* although *Nymphæa* and *Castalia* intermingle in the same beds. *Brasenia* does not occur in the Douglas Lake region.

Respiration.—Respiration in the first instar is apparently cutaneous. Tracheal gills have not yet appeared and, since the larva is almost constantly submerged, it would appear that it must of necessity utilize the dissolved oxygen of the water by absorption through the body-wall. Larvæ, hatched and reared in the laboratory, almost invariably sought the lower side of the water-lily leaf regardless of whether the leaf was submerged or floating. A study of the various situations in which the larvæ of *N. maculalis* occurred most abundantly showed that the water contained a considerable amount of dissolved oxygen, due to the exposure to the air and the agitation by wind and wave action. It is possible that the oxygen demands of the larva in the first instar are low enough that they can be satisfied by the cutaneous form of respiration and special organs are not demanded.

After the first ecdysis, tracheal gills appear, each gill containing a primary branch from the longitudinal tracheal trunks. The appearance of about fifty gill filaments in the second instar would seem to be ample provision for the increased oxygen demand. The marked increase in the number of gills and in the number of branches of each gill in the later instars has been discussed.

The occasional appearance of larvæ on the upper surface of the leaf seems to indicate an ability to pass at least a limited time out of water. Instances of pupation on the upper surface of the leaf were observed in the field and the time required for a larva to emerge from the water, locate the case, and construct the silken inner covering would seem longer than the individual could survive without some form of oxygen supply. No data were secured on the mode of respiration under these conditions.

Possibly, cutaneous respiration continues to be operative in the later instars.

Dissemination.—The larvæ have several methods of dispersal:

(1) Since *N. americana* grows in beds in which the leaves are very frequently contiguous or overlapping, the larvæ hatching from a single egg mass may, by crawling, scatter over a number of leaves. The older larvæ are more efficient at crawling and may ultimately get a considerable distance from the original food plant.

(2) Larvæ may propel themselves in detached cases from one food plant to another as already described.

(3) Wind, wave action, and currents are sometimes very effective in scattering detached cases containing larvæ.

(4) Water-lily leaves, broken from the petioles by wave action or loosened by the attacks of certain species of insects, frequently bear the attached cases of *N. maculalis* and such leaves float about from place to place at the will of the waves and currents. This form of dispersal was very common in some of the water-lily beds about Douglas Lake, where the plants were badly affected by the larvæ of *Hydromyza confluens* (Welch, '14a, pp. 139-140) which cause the petiole to break under very slight side to side strains, and by the larvæ of *Bellura melanopyga* (Welch, '14b, p. 104) which sometimes sever the leaf from the petiole near the upper end of the latter.

Pupa (Pl. VIII, Figs. 6–7).

Forbes ('10, p. 222) gives the following brief description of the pupa: "*Pupa* similar in general form to that of obscuralis, as described by Dyar, but of the seven ridges near the tip of the abdomen beneath, only the central one remains, and the anal opening is not distinctly Y-shaped. The case for the hind legs varies considerably in length." Measurements of a large number of pupæ showed that there is some variation in size. The length, exclusive of the spike-like setæ on the vertex, varies from 10 mm. to 14.5 mm., average 12.6 mm. The maximum diameter is in the region of the second to the fourth abdominal segments and, in the specimens examined, the average is 3.4 mm., the extremes being 2.0 mm. and 4.0 mm. The color is uniformly light yellow, except in specimens about ready to transform in which the developing colors of the adult begin to show through the pupal integument. Pupæ preserved in alcohol lose the yellowish appearance and become whitish. The body is rather soft, smooth throughout, naked, and semi-opaque. The anterior region tapers slightly cephalad while the posterior region tapers distinctly caudad. The abdomen is bent so that the ventral surface of the body is nearly plane while the dorsal surface is distinctly convex.

The head is smaller than the prothorax. It bears on the vertex two slender, porrect, very slightly dehiscent setæ, reddish brown in color, and approximately 0.21 mm. in length. In the older pupæ, the eyes are dark in color and show through the integument. The antennal cases lie parallel to the second leg cases, extending with the latter around on the ventral surface of the body and approaching the mid-ventral line. In the specimens examined, the length of these antennal cases varied, depending, apparently, upon the age of the pupa. The extent of the variation is from a position opposite the first pair of abdominal spiracles to the posterior tips of the wing cases. They acquire an external segmentation corresponding to the segmentation of the antennæ within and have a distinctly moniliform appearance. From the ventral surface of the head, a long, tapering, double sheath extends caudad along the mid-ventral line of the body to a point approximately opposite the tips of the wing cases. It contains in its cephalic end the developing palpi and proboscis.

The thoracic segments and their associated parts are similar in color and appearance in the newly transformed pupæ. On the ventral surface, the cases for the wings and legs cover the greater part of the first four abdominal segments. The tips of the wing cases extend almost to the caudal margin of the fourth abdominal segment. The ventral sheath, for the hind legs, is prolonged caudad almost to the tip of the abdomen. As stated by Forbes ('10, p. 222), the length of this ventral sheath varies considerably. In the large number of pupæ examined by the writer, the caudal extremity varies in position from the caudal margin of the sixth abdominal segment to the posterior end of the body, a variation represented in extent by the combined width of the three posterior segments of the abdomen. The sheath for the second pair of legs also varies in length. It often extends but little if any beyond the tips of the wing cases, but specimens have been studied in which it extended to the caudal margin of the fifth abdominal segment. The case for the first pair of legs is shorter than the others, the posterior extremity usually reaching a point opposite the spiracles on the third abdominal segment, although this case is likewise subject to some variation in length. Observations on pupæ of different ages lead the writer to believe that the length of the leg cases is dependent, to some extent at least, upon the degree of development of the quiescent stage, the length increasing as the time of emergence of the adult approaches. All of the appendages of the head and thorax become more and more apparent and it is often possible to pick out the female pupæ by the uniform dark slaty gray appearance of the front wings. The leg cases become increasingly distinct and acquire an external segmentation corresponding to that of the enclosed leg.

The abdomen is widest at its junction with the thorax and tapers gradually caudad. Except at the extreme posterior end of the body, the intersegmental grooves are broad and well-defined. The second, third, and fourth abdominal segments bear each a pair of large, lateral, conspicuous spiracles, all of nearly uniform size, and borne on fleshy, conical tubercles. The slit-like opening is transverse in position and surrounded by an almost circular, dark orange, chitinized peritreme. Separated from the peritreme by a narrow space and at a slightly lower level is a fine, brown, concentric line. The various structural elements of these spiracles vary in size in the different specimens and to a limited extent in the same specimen. The average dimensions of the peritreme are about 0.232 x 0.264 mm., the average length of the slit-like opening is approximately 0.14 mm., and the average diameter of the outer ring is about 0.28 mm. Vestigial spiracles occur on abdominal segments V–VII but are so inconspicuous that close examination under magnification is usually required to locate them. The ventral surface of the tip of the abdomen bears a number of short, longitudinal carinæ, arranged in two groups. The intersegmental grooves in this region are obscure and careful examination is required to determine the segmental position of these groups of carinæ. The anterior group occurs on the eighth abdominal segment and usually consists of a single, median carina or a pair of similar carinæ, one on either side of the median line. The second group of carinæ occurs near the anterior margin of the ninth abdominal segment and consists of a single, median carina separating the components of a pair of similar carinæ. Sometimes a second pair of lateral carinæ are also present. The crests of the carinæ in both groups are brownish in color while the sides have the same color as the adjacent parts of the abdomen.

The number and arrangement of these carinæ on the ventral surface of the ninth abdominal segment present considerable variation. Forbes ('10, p. 222) states that this pupa is similar in general form to that of *N. obscuralis* "but of the seven ridges near the tip of the abdomen beneath, only the central one remains". The writer has examined a large number of these pupæ during the past five summers and has failed to find a single pupa which possessed only the single, median carina. The first pair of lateral carinæ is always present in addition to the median one and, as stated above, there is sometimes present a second pair laterad of the first. When a second pair is present, the component carinæ are usually smaller than the other carinæ and not so readily distinguished. In *N. obscuralis*, as described by Hart ('95, p. 173), the first group of elevations are described as follows: "Apex of abdomen subacute; ninth segment beneath with a faint elevated line at middle, and a small elevation each side." In the figure accompanying this description, the "small elevation each side" is represented as circular in contour. This condition seems distinctly different from that existing in *N. maculalis* since, in all of the pupæ examined, the single elevated line, when present, is unaccompanied by conical elevations of any sort, and when absent, it is represented by a pair of similar, longitudinal elevations. Furthermore, this group of elevations is on the eighth abdominal segment. The above description probably does not include all of the variations which exist since the writer found one specimen in which the anterior group of carinæ consists of three pairs of elevations, diminishing in size on either side.

Caudad of the second group of carinæ is a distinct Y-shaped impression. Forbes ('10, p. 222) makes the following statement: " . . . . and the anal opening is not distinctly Y-shaped." All of the specimens examined in this connection show this ventral impression to be of such structure that the expression "Y-shaped" describes it quite well.

As already stated, the full-grown larva usually attaches its case to the lower, submerged surface of a water-lily leaf and transforms into the pupa. Just before pupation, a dense, whitish, apparently complete, silken covering is spun around the larva. This silken covering adheres closely to the inner walls of the case and is strongly attached at the periphery. It is elliptical in outline, the dimensions usually being about 1.25 x 2 cm. The maximum thickness is usually but little more than the maximum diameter of the pupa. This silken covering is relatively strong and not easily torn open.

The case varies to some extent in size and shape. In general, it is elliptical and has dimensions varying from 1.5 x 2 cm. to 2.5 x 5 cm. The vast majority of the pupal cases are attached to the lower surface of the floating water-lily leaves and are thus constantly submerged. Pupal cases have been found on the upper surface of floating water-lily leaves, a position which minimizes contact with the water. The fate of such pupæ is not known. A few pupal cases have also been found on the submerged water-lily leaves, several inches under the surface of the water.

The external surface of pupæ is not easily wetted and they float if removed from the silken coverings and placed in water. The fate of pupæ which accidentally become removed from their cases is not known. It is said (Miall, '95, p. 233) that the pupæ of certain European species of *Nymphula*, when removed from their silken coverings and placed in water, live for a time but do not transform into adults.

Dissemination.—In connection with the discussion of the dissemination of the larvæ, mention was made of the fact that an indirect method of distribution occurs, due to the influence of wind and waves, or the work of other insects, or both. The pupæ are sometimes scattered in the same way. The work of the larvæ of *Hydromyza confluens*, *Bellura melanopyga*, and others, frequently bring about the separation of the leaf or portions of the leaf from the petiole, permitting them to float about at random. Such detached leaves often bear pupal cases of *N. maculalis* and may be carried some distance from the original breeding place. After storms in which portions of the floating water-lily leaves are torn away by wave action, pupæ are sometimes found on the opposite shore.

THE ADULT.

Adults of *N. maculalis* have been taken about Douglas Lake by the writer from June 28 to August 30 but these limits are probably too narrow. They are normally confined to the region surrounding the food plants of the larva and the few scattering adults which are sometimes found remote from yellow water-lilies are probably individuals which have emerged from pupæ which have been drifted away from the original breeding place by the wind and waves, rather than individuals which have voluntarily wandered from the place of emergence.

The adults of *N. maculalis* are largely nocturnal in habit. Occasionally, individuals may be observed in flight during the day but, in general, the period of activity begins shortly after dusk. During the day, they can usually be driven to flight by walking through the water-lilies or in the vegetation growing near the edge of the water, or by beating the undergrowth fringing the beach near the water-lily zone. On calm, clear days, adults are commonly found at rest upon the upper surface of the water-lily leaves, but on windy days they usually seek the undergrowth near the edge of the beach. They respond readily to slight disturbances by short flights but observations both in the field and in the aquarium lead the writer to believe that voluntary flight during the day is not common. Females in the breeding cages remain inactive throughout the entire day. Diurnal flight is apparently at random and the selection of objects of support a matter of chance. Only one constant feature was observed, namely, adults never made long flights away from the immediate vicinity of the water-lily beds. Individuals, driven from resting positions, often flew over the open water, never rising high above the surface, dropping momentarily on the surface from time to time, but almost invariably, after a flight of three or four rods, returning to the same vicinity. Individuals which happened to fly out from shore during a strong wind had difficulty in returning and were frequently carried far out on the lake.

The adult apparently suffers little if any from contact with water. The usual position of the pupa is such that, on emergence, the adult is, of necessity, compelled to come to the surface through a certain depth of water. Individuals flying over open water, as described above, frequently drop momentarily on the surface, taking wing again without difficulty. Individuals, whose powers of flight have been exhausted, drop ultimately to the surface and may rest there for a considerable length of time.

Nothing was discovered concerning the feeding habits of the adult. Individuals have lived for days in an aquarium without food but the possession of well-developed mouth parts points rather definitely to a feeding habit.

Only incidental observations on the enemies of this species were made in this connection. It is probable that the possession of a case in the larval and pupal stages is a provision whereby considerable protection is afforded. The larvæ occur in situations which are rich in predaceous animals of several kinds and there is no reason to suppose that such fleshy larvæ would be exempt from attack. One of the robber-flies, common in the Douglas Lake region, preys on the adult and specimens of the latter have been taken with adult *N. maculalis* in their claws. Although this robber-fly is a vigorous enemy, it seems probable that the nocturnal habit of the moth prevents greater fatality from this enemy.

Nymphula icciusalis Walker.

Early Stages.

Nymphula icciusalis is abundant on the north shore of Douglas Lake about the bays, beach pools, and inlets, all of which contain quantities of *Potamogeton*, *Vallisneria*, and other aquatic plants. By confining females in aquaria containing the leaves of several aquatic plants, egg masses were easily secured and the process of hatching and the early development of the larva were observed. Since the early stages of the life history have not been described, the following data have been included in this paper. Packard ('84, p. 824) figured a larva, which he supposed to be *N. icciusalis*. Forbes ('10, pp. 225–6) reared a single larva through to maturity and reported close correspondence of data with those of Packard, but made no mention of the eggs or early larval instars. Miller ('12, pp. 127–134, 245) made some observations on this species, described some of the activities of the larvæ, made slight mention of the pupa and of the eggs, and described the full grown larva in considerable detail.

THE EGG.

Place and Method of Deposition.—The following data were taken from egg masses deposited by females in the aquaria and from numerous egg masses taken in the field. Egg masses from both sources were laid on the leaves of *Potamogeton natans*. In aquaria containing only *Nymphæa americana*, females, after some delay, deposited eggs on the leaves of this plant in the characteristic way but this was evidently not a normal reaction.

Eggs are laid in a definite cluster on the lower surface of the leaf and very near the margin. No egg masses were found in connection with punctures or artificial breaks through the leaves. The eggs are arranged in concentric rows, usually four, which are separated by uniform spaces, each row being curved so that the concave side is always towards the margin of the leaf. The number of eggs composing the clusters examined in this connection varies from 17 to 76. Clusters are sometimes placed so closely together that they appear to be almost confluent. The row of eggs nearest the margin of the leaf is always at least 2 mm. from the edge and sometimes as much as 5 mm. Oviposition was not observed but the position of the egg mass and the distance of the rows from the edge of the leaf indicate that possibly the female lays the eggs, in a manner similar to that suggested for *N. maculalis*, by clinging to the edge of the leaf, extending the ovipositor under the edge and swinging it around, thus depositing the eggs in concentric rows.

Description.—The eggs are elliptical in outline, slightly flattened, smooth, uniform in size, and 0.45 mm. x 0.6 mm. in dimensions. They are whitish in color, being distinctly lighter than the leaf surface on which they are placed. When first laid, they show no external signs of internal differentiation.

Development.—The egg period is from ten to eleven days. Eggs, deposited in the aquaria, develop in the same way and at the same rate as the egg masses collected in the field. During the first two days subsequent to oviposition, no internal changes are evident. At the end of about fifty hours, the eggs begin to show signs of internal differentiation and, during the following 24–36 hours, a dark band develops within, similar in some respects to the one which appears in the early development of the eggs of *N. maculalis*. This band has a shape somewhat like the letter J and is constant in its position in all of the eggs, the more curved end of the band being invariably in the end of the egg remote from the edge of the supporting leaf. After five days of development, the dark band has increased considerably in size and has changed somewhat in shape, showing distinct differences in the two ends, one being larger and more blunt and recognizable as the future head of the caterpillar. During the seventh to the ninth day, the black areas on either side of the head appear and the longitudinal tracheæ are visible. The tips of the mandibles are also turning brown. At the end of the ninth or the beginning of the tenth day, the outlines of the complete caterpillar are visible through the egg capsule. It is coiled upon itself, the caudal end reflected around the head, and the dorsal surface usually turned from the surface of the leaf. The dark, chitinized head capsule and prothoracic shield are the most conspicuous parts. The intersegmental grooves are visible to a slight degree. The abdomen and the two posterior segments of the thorax are devoid of dark color or markings. At this stage, the mandibles are observed to be in active motion and contractions of the body preliminary to hatching are evident.

THE LARVA (Pl. VIII, Fig. 11).

First Instar.—Larva small; length about 1.4 mm.; maximum diameter of head 0.25 mm. Body whitish; translucent; head and prothoracic shield very dark-brown and heavily chitinized; remainder of body devoid of dark color and quite flexible. No tracheal gills. Principal setæ as in figure 11. Anal setæ 0.14 mm. long. Dorsal surface of segments often showing transverse folds and wrinkles. Prolegs with hooks arranged in transverse ellipse; usually 22–24 hooks on each body proleg; about 7–9 hooks on anal prolegs.

Case-making.—Small, elliptical cases, 2.5–3 mm. long, are constructed soon after hatching. They may be attached or independent and the leaf material may be cut from the periphery or from the middle of the leaf. The young larvæ show a very distinct tendency to remain on the lower sides of the leaves where all of the work of excising pieces of leaves is done. Cases are outgrown and new ones constructed, much as has been described for *N. maculalis*, and they seem to serve similar functions. Attached cases usually occur on the lower side of the supporting leaf.

Food.—Packard ('84, p. 825) found his supposed larva of *N. icciusalis* making cases from the leaves of *Menyanthes trifoliata.* Forbes ('10, p. 226) reported his specimens on *Potamogeton* and states that they would not eat *Limnanthemum.* Miller ('12, pp. 127, 130) found caterpillars feeding on *Potamogeton natans* and states that they may also work on *Marsilia quadrifolia.* The egg masses, larvæ, and pupæ occur predominantly on *Potamogeton natans* in the Douglas Lake region, although a few larval cases were found, in part, composed of fragments of leaves of *Vallisneria*, a fact which suggests that this plant may be used for food. No evidence of feeding on any of the water-lilies was observed. The larvæ are active from the moment of hatching and soon begin feeding, evidence of which is the early appearance of yellowish matter in the digestive tract.

SUMMARY.

Aquatic Lepidoptera are very limited in number and the American species are little known. They rival other aquatic insects in the character of their unique habits and adaptations. Two species are considered in this paper.

I. *Nymphula maculalis* Clem.

1. Eggs are deposited only on the lower, submerged surface of the leaves of the yellow water-lily, *Nymphæa americana*, in masses arranged in concentric rows.

2. Egg masses, in the Douglas Lake region, are invariably placed about the egg holes of the chrysomelid beetle, *Donacia*.

3. Laboratory observations and experiments on females in aquaria yielded the following data: (a) Eggs were invariably deposited at night. (b) Eggs were invariably placed about *Donacia* egg holes when the latter were available. (c) Oviposition may extend over five successive nights. (d) One female may use several *Donacia* egg holes before oviposition ceases. (e) Maximum number of eggs laid by a single female was 617. (f) In the absence of *Donacia* egg holes or other similar punctures in the water-lily leaves, oviposition was usually delayed but ultimately resulted in the deposition of small egg masses on the lower side of the leaves at the margins. Egg masses were deposited about artificial punctures and incisions of various sizes and shapes, the dimensions of which apparently had little to do with the selections.

4. The egg period is about eleven days. There is a definite and constant orientation of the eggs in the mass since the heads of the larvæ invariably develop in the ends of the eggs nearest the leaf puncture.

5. The larva in the first instar is devoid of tracheal gills and respiration is apparently cutaneous.

6. Tracheal gills first appear in the second instar. Paired, lateral, filamentous gills occur on all of the segments except the prothorax and the last abdominal. Maximum number of gills per segment is two.

7. In the third instar, an increase in the number of gills appears, the maximum number being three. Dorsal, paired, filamentous gills also appear.

8. The sole method of locomotion by larvæ is an inefficient crawling. There is no evidence of an ability to swim. When supported by a case, change of position can be effected by side to side motions of a portion of the body extended into the water.

9. Case-making is a constant larval activity from time of hatching to pupation and sometimes seriously reduces the leaf surface of the food plants. The chief functions of the case seem to be (1) protection, and (2) support in the water.

10. No evidence of feeding or case construction which involved plants other than *Nymphœa americana* was observed, although the larva has been reported in connection with *Castalia* and *Brasenia*.

11. After the first instar, tracheal gills constitute the larval respiratory organs. The maximum number of gills increases with advancing age from two per segment in the second instar to as many as ten per segment in the mature larva. The total number of gills increases from twenty-two in the second instar to one hundred in the mature larva. The number of gill filaments per segment increases from four in the second instar to as high as forty-eight in the full-grown larva. The total number of gill filaments on the body of a larva increases from forty in the second instar to over four hundred in the full-grown larva.

12. Dissemination in the larval stage is accomplished by crawling over contiguous leaves; by voluntary propulsion in detached cases; by the effects of winds, waves, and currents on detached cases; and indirectly by the work of certain other insects which cause a separation of the leaves of the food plant from the petiole.

13. The pupa is described in detail. It is usually attached to the lower, submerged surface of the water-lily leaf and is enclosed in a silken covering which, in turn, is surrounded by the last larval case.

14. Pupæ are disseminated by indirect methods. Winds and waves, assisted by the work of certain insects, may scatter pupal cases widely.

15. The adult moth is largely nocturnal in habit. It suffers little, if any, from contact with the water, and in extended flights over water may drop to the surface for short rests.

II. *Nymphula icciusalis* Wlk.

16. Eggs are deposited on *Potamogeton natans*. In the aquaria, females, in the absence of *Potamogeton*, deposited eggs, after some delay, on *Nymphæa americana*.

17. Oviposition is independent of the activities of other animals.

18. Development of the egg requires ten or eleven days. As in *N. maculalis*, there is a definite and constant orientation of the egg, when deposited normally, since the head of the larva always develops in the end nearest the edge of the leaf.

19. The first instar is described for the first time.

20. Case-making, similar to that of *N. maculalis*, is a normal activity of this larva. The great majority of the cases studied were made from leaves of *Potamogeton natans* but a few were composed, in part, of fragments of leaves of *Vallisneria* which possibly is another food plant.

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November 1, 1915.

EXPLANATION OF PLATES.

Plate VII.

Figs. 1-10. *Nymphula maculalis.*

Fig. 1. Dorsal view of recently hatched larva.

Fig. 2. Dorsal view of larva in the second instar.

Fig. 3. Dorsal view of larva in the third instar.

Fig. 4. Egg as it appears immediately before hatching.

Fig. 5. Egg masses on lower surface of leaf of *Nymphæa americana. p,* puncture through leaf made by female *Donacia; d,* eggs of *Donacia* sp.; *n,* eggs of *Nymphula maculalis.*

Plate VIII.

Fig. 6. Ventral view of pupa.

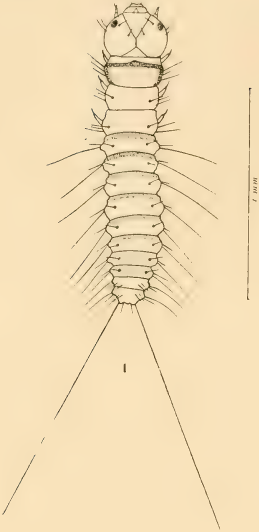
Fig. 7. Lateral view of pupa.

Figs. 8-10. Ventral view of terminal segments of pupa, showing some common forms of variation in number and arrangement of carinæ.

Fig. 11. Dorsal view of larva of *Nymphula icciusalis.*

Plate IX.

Figs. 12-19. Leaves of *Nymphæa americana* showing characteristic work of larvæ of *Nymphula maculalis.* Figs. 12, 13, 14 and 17 show extent to which surface of food plant may be reduced. In Figs. 13, 16 and 19, the small marginal incisions are the work of young larvæ. In Figs. 12, 14 and 17, the broad marginal incisions were produced by full-grown larvæ.



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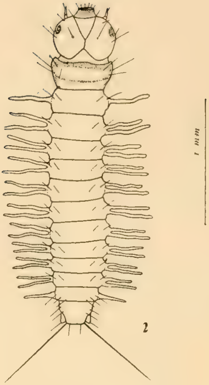

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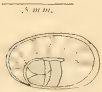

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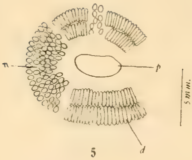

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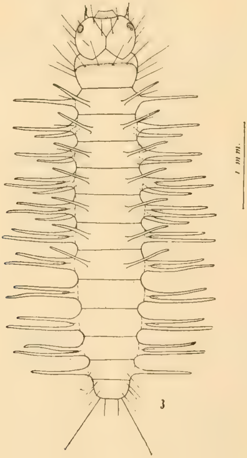

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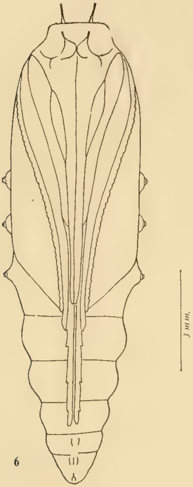

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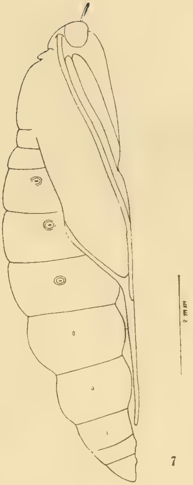

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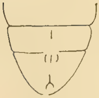

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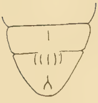

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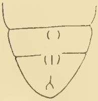

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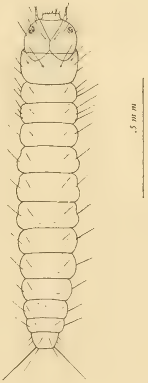

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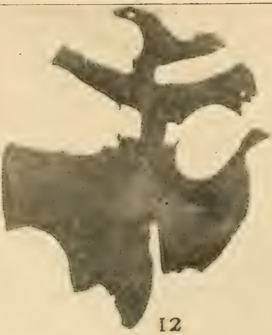

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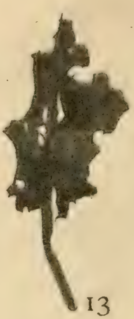

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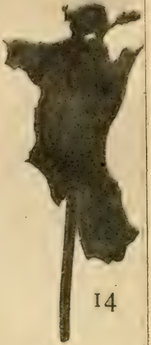

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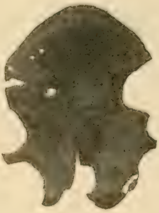

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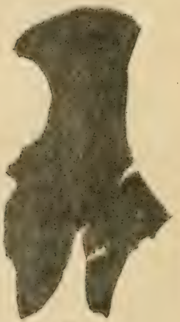

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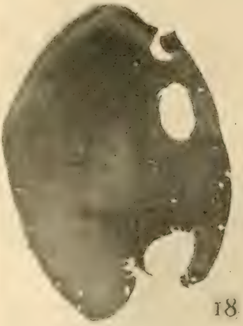

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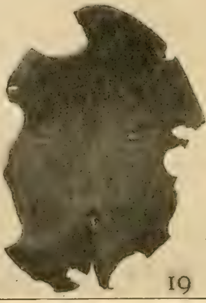

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P. S. Welch.

SYNOPSES OF ZODION AND MYOPA WITH NOTES ON OTHER CONOPIDÆ.

Nathan Banks.

For several years I have been accumulating material in this family, and the occasion of determining some western material induces me to publish descriptions of certain new species and to tabulate two of the genera, *Myopa* and *Zodion*, although the table of the latter genus is rather unsatisfactory.

These insects, like most parasitic ones, are variable in size; thus our two Eastern Occemyias cannot be separated by size as has been stated, each of them having large and small specimens. In the Myopinæ several species are widely spread, thus *Myopa vesiculosa* and *Zodion fulvifrons* occur in California as well as the East, and *Myopa pilosa* which was described from California is probably the same as our Eastern *M. vicaria;* also *Zodion pygmæum* from California and Nebraska seems to agree with our Eastern *Z. nanellum*, *Myopa clausa* I have from Utah, and *Zodion perlongum* and *Z. parvum* described from New Mexico and Arizona occur here in Virginia. *Z. obliquefasciatum* is also widely distributed, and *Occemyia loraria* occurs in Oregon as well as the East. In the Conopinæ, the species are more local, and the Western and Southwestern species are different from the Eastern ones; the Western species usually with more yellow upon them.

Conops arizonicus n. sp.

Face whitish, cheeks wholly pale, front and vertex dark rich brown, except that the white extends up as a narrow silvery stripe on inner orbits, and the dark extends down a little on the facial ridges. Antennæ dark brown, the third joint fully one and one-half times as long as the second; thorax and abdomen black, shining; last segment of abdomen more grayish pollinose and transversely wrinkled; hypopygium mostly shining black; legs blackish, extreme tips of the femora and basal half or third of tibiæ pale. Vertex, thorax, abdomen and legs with short blackish hair; wings with large costal dark cloud to end of second vein, extending directly downward to tip of the fifth vein; extreme tip dark. These marks are like those of *C. sylvosus*, except that here the cloud extends unbroken to the fifth vein and the abdomen does not show pale bands; halters pale. The ventral plate is not as large as in *C. sylvosus*.

Length, 7 mm.

From Palmerlee, Ariz., Aug. (Biederman). It is distinguished from *C. sylvosus* by the much longer third joint of antennæ, and the second joint not quite as long as in that species.

Conops brachyrhynchus var. **semifuscus** n. var.

Agrees with the type in structure and general coloration. The femora are almost wholly pale; the pale mark on tip of second and base of third abdominal segment is much longer, the last segment and basal part of hypopygium more yellow; the humeri yellow pollinose and the dark of wings stops at the third vein (in *C. brachyrhynchus* the dark gradually fades off.).

From Jemez Springs, N. Mex., 6 July (Woodgate).

Zodion.

In this genus are a number of closely related species; several of the Eastern forms are best separated by the shape of the ventral plate of the female. The forms intermediate in size I have placed twice in the following table, since they vary in size. *Z. fulvifrons* sometimes has the first posterior cell closed, so it also occurs twice in the table.

1. Thorax and abdomen gray, with very distinct black spots; legs pale, also with black spots.......... *pictulum*
Thorax, abdomen and legs with only indistinct black spots or with lines or streaks.......... 2
2. Thorax with two pale submedian stripes, abdomen largely pale, with oblique dark bands.......... *obliquefasciatum*
Thorax without pale stripes.......... 3
3. Palpi rather long, clavate.......... *palpalis*
Palpi minute, cylindric.......... 4
4. Very small species, hardly over four millimeters.......... 5
Larger species, nearly six or more millimeters in length.......... 9
5. Last joint of antennæ wholly pale; first posterior cell closed.......... 6
Last joint of antennæ wholly pale; cell open; legs black, abdomen not marked with pale.......... *triste*
Last joint of antennæ dark at tip.......... 7
6. Cell petiolate; abdomen of ♂ mostly dark.......... *parvum*
Cell closed in margin; abdomen of ♂ mostly pale.......... *abdominale*
7. Cell short petiolate; basal part of ♂ abdomen pale yellowish.......... *scapulare*
Abdomen black with gray marks; cell open.......... 8
8. Eastern specimens.......... *navellum*
Western specimens (probably the same).......... *pygmæum*
9. First posterior cell closed.......... 10
First posterior cell open.......... 12
10. Abdomen of ♂ pale yellowish at base; last joint of antennæ dark at tip. *scapulare*
Abdomen not paler at base; last joint of antennæ not dark at tip.......... 11
11. Thorax gray with two or three dark stripes; abdomen not usually pale. *fulvifrons*
Thorax not so plainly marked, abdomen of ♂ pale yellowish..... *abdominale*

12. Thorax not plainly striped; western species 13
Thorax more distinctly striped 14
13. Legs mostly dark, abdomen wholly dark .... *triste*
Legs pale, last abdominal segments pale .... *obscurum*
14. Proboscis from palpi to tip fully twice the head height; abdomen pale in male, Western species .... *reclusum*
Proboscis not so long 15
15. Thorax gray, with two or three dark stripes above beside lateral spots; ventral plate broad and low .... *fulvifrons*
Thorax brownish, with four or five dark stripes, beside lateral spots; the intermediate stripes distinct only in front 16
16. Ventral plate fully twice as long as broad, abdomen of female very slender and compressed; male with pale abdomen .... *perlongum*
Ventral plate shorter 17
17. Ventral plate much broader than long; the striated dark area behind also broad .... *sayi*
Ventral plate as long as broad 18
18. Ventral plate about one and a half times as long as broad, Eastern species. *intermedium*
Ventral plate about as long as broad, Western species .... *occidentale*

Zodion fulvifrons Say.

Say says that the thorax has two distant brown lines. This plainly agrees only with *Z. abitus* Adams; the first posterior cell varies from open to closed. I have therefore no hesitation in considering *Z. abitus* a synonym of the true *Z. fulvifrons*. *Z. rufifrons* Macq. was from Philadelphia. He says the thorax with "nuance de cendre argente" which will apply far better to *Z. fulvifrons* than to any other Eastern species. The rest of his description will fit any of our Eastern species. *Z. fulvifrons* has the ventral plate low, and much broader than long.

Zodion perlongum Coq.

Described from the West, it occurs here in Virginia. The long, compressed abdomen, and the very long ventral plate will distinguish the female. What I believe is the male has a rather pale abdomen. Mr. Greene has taken it at Broomall, Pa. Most of the specimens are taken in September.

Zodion intermedium n. sp.

Face whitish, antennæ reddish, front fulvous, in some specimens much darkened on the vertex and the dark reaching forward in a forked stripe; thorax above brown, with four black stripes, the intermediate pair only in front, the sublateral pair not extending forward, lateral spots, and transverse suture often black; metanotum dull black. Abdomen black, yellowish gray pollinose, especially on sides and a middle stripe; legs pale, femora dark above, last tarsal joint black; wings rather yellowish on base, veins beyond base dark. Vertex, thorax, abdomen and legs clothed with black hairs. Proboscis beyond palpi about one and one-half times as long as head-height. Ventral plate of female about one and one-half times as long as broad, narrowed toward tip, behind at tip the dark striated area is very narrow. Posterior cell open.

Length 7.5 mm.

From Pocono Lake, Pa., and Clementon, N. J. May and July, all from Mr. C. W. Greene. Cotypes in his and author's collection.

Zodion sayi n. sp.

Very similar to *Z. intermedium*, but smaller. Face, front, antennæ, thorax, abdomen and legs colored and marked as in that species. The wings also the same, first posterior cell open. Pubescence and pollen as in that species. The proboscis is rather shorter, from palpi to tip about once and a fourth the eye-height. The ventral plate is very different from *Z. intermedium*, and similar to that of *Z. fulvifrons* (*abitus*) being low, much broader than high, and behind with a very broad, dark striated area.

Length, 6 mm.

From Falls Church, July and Sept., and Mt. Jefferson and Horse Lake, Oregon, July (Lovett). Males from Mt. Graybeard, N. Car., May, and La Quintina, Cal., probably belong here. I have named it in honor of him whose description of *Z. fulvifrons* was sufficiently accurate to enable me to describe this form.

Zodion occidentale n. sp.

Face whitish; front golden, darker on the vertex, with the dark spots on the middle toward the antennæ; occiput largely black; antennæ reddish, third joint as long as the second, arista black; thorax brownish gray, with the usual stripes distinct, except the median one, which is faint. Abdomen brownish gray, paler near tip, indistinct blackish spots near middle; legs yellowish, femora often blackish above; tarsi darker, last joint black. Wings gray hyaline, veins dark. Vertex thorax, abdomen and legs clothed with rather long, black hair. Cheeks more than one-half eye-height; proboscis rather short. Ventral plate a little longer than broad.

Length 7.5 to 9 mm.

From Montaville, Mary's River, and Corvallis, Oregon, May and July (Lovett). Cotypes in collections of Oregon Agricultural College and that of author.

Zodion obscurum n. sp.

Face whitish, front golden, a brown median stripe reaching forward from the ocelli; antennæ reddish, arista mostly pale, third joint fully as long as the second; occiput mostly black. Thorax black, gray pollinose, not showing distinct stripes. Abdomen black, gray pruinose, last segment red, hypopygium reddish on basal part, black on apical part; legs yellowish, tarsi darker. Wings nearly hyaline, venation mostly black. Vertex, thorax, abdomen and legs clothed with black hair. Cheeks hardly one-third of eye-height; proboscis moderately long; first posterior cell open. Ventral plate very broad.

Length, 5.7 mm.

From Bear Valley, San Bernardino Co., 6700 feet, and Santa Monica, both Cal. (Clark). Type in collection of author.

Zodion reclusum n. sp.

Face pale yellowish white; front golden, vertex brown, limited transversely in front, antennæ reddish, arista black, third joint about as long as the second; thorax brownish gray, with the fine stripes brown, the submedian very short, the lateral indistinct. Abdomen yellowish gray, with brown marks near middle, leaving a pale median stripe, basal segment gray; legs yellowish, femora usually blackish above. Wings brownish, venation mostly black. Vertex, thorax, abdomen and legs clothed with black hair. Cheeks not one-third the eye-height.

Length 6.5 mm.

From Redlands, Cal., Nov. (Cole) and Corvallis, Oregon, (Bridwell). Cotypes in collections of Oregon Agricultural College and that of the author; both males.

Zodion lativentre Graenicher.

I do not know this species. A male of what I have called *Z. perlongum* was sent Dr. Graenicher for comparison, but he said his species was very different from it.

Zodion abdominale Say.

The size is given as smaller than *Z. fulvifrons* (*abitus*), and the abdomen pale like the femora. This agrees well with *Z. bicolor* Adams; moreover, Say's statement about the color of the veins fits this species particularly well. The thoracic marks also agree.

Zodion triste Bigot.

Bigot says little of marks on thorax, and I have identified as this species provisionally a form from the West, which is small, has dark legs, and almost unmarked thorax.

Myopa.

In the following table of the species in my collection I have depended largely upon color; the color of the hair is very important; but the amount of reddish on thorax and abdomen in certain species is doubtless variable.

1. Wings with distinct dark clouds over the cross-veins; abdomen black-haired . . . 2
   Wings without clouded cross-veins . . . 4
2. Face with rather short hair; a cloud in first posterior cell, which is closed, small species . . . *melanderi*
   Face with long white hairs, forming a fringe below; first posterior cell open . . . 3
3. Face with several small black spots on each side, dark clouds in both first and second posterior cells . . . *willistoni*
   Face at most with a reddish spot each side above, no clouds in posterior cells. *vicaria*
4. Thorax and abdomen with short appressed white hairs . . . 5
   Thorax and abdomen with black hair . . . 6
5. Abdomen mostly reddish; costal cell not much darkened, *vesiculosa var. varians*
   Abdomen mostly black; costal cell very plainly blackish . . . *vesiculosa*
6. The hairs on thorax above are hardly one-half as long as the arista; abdomen also with very short hair . . . 7
   The hairs on thorax above as long as the arista; abdomen also with long hair . . . 9
7. Abdomen wholly red; hairs of body are extremely short . . . *seminuda*
   Abdomen largely black . . . 8
8. Abdomen reddish on sides and behind; fifth segment not divided by a median pollinose pale streak . . . *plebeia*
   Abdomen not reddish; fifth segment with a median stripe of pale pollen. *virginica*
9. Abdomen mostly black . . . *longipilis*
   Abdomen mostly red . . . 10
10. Proboscis very long, the second joint as long as femur I, the last joint as long as the second . . . *clausa*
    Proboscis with the second joint only about two-thirds as long as the front femur, the last joint a little shorter than second . . . *rubida*

Myopa vesiculosa Say.

This species is readily known by the white hair of body; it occurs both East and West, specimens are before me from Washington State, and the *conjuncta* of Thompson from California may possibly be the same species.

Myopa vesiculosa var. **varians** n. var.

Structurally like the typical form, but rufous throughout, and the wings lack the dark cloud through the middle area. The antennæ are a trifle shorter, but this may not be constant.

From Lincoln, Neb. Sent me by Mr. P. R. Jones as his idea of *Myopa clausa*.

Myopa vicaria Walk.

The description of *M. pilosa* Will. fits this species very well, but I have not seen any Californian examples and it may be distinct.

Myopa willistoni n. n.

M. pictipennis Will. preoccupied by *M. pictipennis* Rob.-Desv. 1830.

This species is distinct from all our other forms, except *melanderi*, by the much thickened femora. The second joint of proboscis is fully two-thirds of the head-height, the third joint is about equal to the second. The hair on the face is not as long as in *vicaria*. The knob of the halters is dark, pale in our other species. I have seen specimens from Oregon and California.

Myopa melanderi n. sp.

Black, face white, with short white hair, front with the usual black V-mark, and spots at the base of the antennæ, latter dark. Head from in front about circular; cheeks scarcely higher than eyes; proboscis black, last joint shorter than second, the latter hardly two-thirds of head-height; second antennal joint scarcely if at all longer than the third. Thorax black, two short, white pollinose stripes in front part. Abdomen, black, posterior margin of segments narrowly white pollinose, rather broader on the sides, a narrow, median, white pollinose stripe over all segments, last segments with only a pair of small dark spots. Legs black, base and extreme tip of femora, base, middle and tip of tibia and the tarsi pale. Front, thorax, abdomen and legs with moderately long black hair. Wings gray, yellowish on base and near stigma; anterior and posterior cross-veins plainly broadened with blackish, and a distinct rounded cloud above the posterior cross-vein in the first posterior cell, latter closed before tip. All femora much thickened as in *M. willistoni*.

Length, 4.5 mm.

From Pullman, Wash., 6 May (Melander).

Myopa clausa Loew.

I have considered as this species a reddish form with extremely long proboscis; it occurs in the East, and I have two from Utah (Spalding), also one from Mt. Graybeard, N. Car.

Myopa longipilis n. sp.

Black, face yellowish white, with fairly long white hair; front brown, showing the usual V-mark; antennæ dark, second joint a little longer than the third; head from in front almost circular; in some specimens a faint dark cloud on each cheek; proboscis black, second joint about two-thirds of head height; third joint about equal to the second. Thorax rather reddish on sides and behind; abdomen reddish toward tip, or on the sides, some of the segments narrowly white pollinose on sides behind. Legs reddish, on the femora largely blackish, except base and tip, tarsi pale. Front, thorax, abdomen and legs with long black hairs, fully as long as in *M. vicaria*. Wings rather pale brownish yellow, without dark clouds.

Length, 9.5 mm.

From Pullman, Wash., April and May (Melander).

Myopa seminuda n. sp.

Face yellowish white, with short white hair, antennæ and front reddish, second joint of antennæ much longer than the third which is usually short; front with the usual brown marks; occiput with large black mark behind each eye, head from in front plainly higher than broad, cheeks fully eye-height; proboscis with second joint not two-thirds of head height, third about equal to second. Thorax red, with three broad black stripes, more or less broken, middle one with a median pale line; metanotum deep black; abdomen bright red, lateral margins of segments barely white pollinose behind. Legs red, tarsi yellowish. Front, thorax and abdomen with extremely short, erect black hairs. Wings brownish, base yellow, costal area also rather yellowish, first posterior cell open or closed.

Length, 9 mm.

From Corvallis, Ore., June, and near base of Mary's Peak, Ore., May (Lovett), Cotypes in Coll. author and Ore. Agric. Coll. The extremely short hair distinguishes the species.

Myopa virginica n. sp.

Black, head yellowish white, face with short white hair; antennæ reddish, second joint much longer than the third; front with dark V-mark extending back and down on the occiput, also in a V. Head from in front plainly higher than broad, cheeks equal eye-height; proboscis dark, last joint paler, and as long as the second, latter about one-half of head height. Thorax with humeri shining, sometimes faintly reddish on sides and behind; abdomen black, first and second segments with lateral white pollinose spots, third fourth and fifth with apical white pollinose margin, broader at the sides, sixth and seventh mostly white pollinose; fourth and fifth segments with a narrow median white pollinose stripe. Legs blackish or brownish, basal part of tibia and most of tarsi pale. Front, thorax, abdomen and legs with rather short, black hair. Wings brownish, base yellow, first posterior cell closed before the margin.

Length, 7 mm.

From Falls Church and Glencarlyn, Va., in June and early July. Also one from the Catskill Mountains, N. Y., June, and one from Black Mountain, Swannanoa Valley, N. C., May. Probably this is the form referred to by Williston in his remarks after the description of *P. vesiculosa* as one specimen from Virginia with black pile.

Myopa plebeia Will.

Described from Arizona, I have seen one from Washington State (Mann.) Although structurally similar to *M. virginica*, it is much larger, and with a very different habitus, however too few specimens are known to me to know if it varies. The *M. castanea* of Bigot is quite probably the same form.

BIGOT'S SPECIES.

G. rubida.

Agrees with a form of *Myopa* common in the West which is close to *M. clausa*, but with a shorter proboscis. I have it from Oregon and Washington.

G. maculifrons.

This is probably *Myopa vesiculosa* which also occurs in the West. The only objection is that Bigot says the hair of thorax is brown (he does not say black).

G. castanea.

Is larger than his other species; the red abdomen, black above, would indicate that it is *plebeia* Will., which agrees also in other characters. Von Roeder's statement that it is *Myopa clausa* is based on the idea that the closed cell is a specific character.

Occemyia abbreviata Lw.

The abdomen of both male and female slightly clavate, whitish on the posterior sides of second segment; hair black; in the female the ventral plate is very broad, low, and dark colored. Hind femora are often pale on basal half, black on apical half. The pollinose marks of abdomen are whitish. The size varies, and three specimens are as small as the smallest *O. loraria*.

Occemyia loraria Lw.

In the male the abdomen is more elongate and cylindric than in *O. abbreviata;* the pollinose marks more yellowish, the hair also yellowish. In the female the ventral plate is narrow, and mostly pale colored. The size varies, and some specimens are as large as the largest *O. abbreviata*. From Oregon (Corvallis) I have seen specimens that I cannot distinguish from the Eastern ones.

Dalmannia pacifica n. sp.

Face pale; in the male a large elongate dark spot each side just outside of the facial ridges, in female wholly yellowish; vertex and front black; thorax shining black, the humeri and scutellum yellow. Abdomen mostly yellowish above and below; first segment black, with a pale band at base and apex broadly pale; segments two and three yellow, with four separated (or barely connected) black spots across base, the lateral spots reaching the side margins; fourth segment yellow, with a black spot on each side, in the female the fifth segment has a pair of black stripes, united behind, and the ovipositor black; venter with a middle black spot on first segment; legs yellow, tarsi black; front and hind femora with some black, mostly above; wings brownish; halters yellow. In structure very close to *D. nigriceps* and *D. picta;* in the venation the second vein ends nearer to the first vein than in *D. picta;* in this respect similar to *D. nigriceps*.

Length, 7 mm.

From Corvallis, Oregon, 4, 6 June (Lovett). Cotypes in collection Ore. Agr. College and that of author. Differs at once from *D. picta* and *D. nigriceps* in the much greater extent of the yellow on the abdomen.

Our four species may be distinguished as follows:

1. Humeri dark; scutellum dark; small species .... *vitiosa*
   Humeri pale, scutellum more or less pale 2
2. Second and third segments yellow with four basal black spots; scutellum yellow .... *pacifica*
   Second and third segments mostly black, with apical yellow margin, more or less indenting the black 3
3. Scutellum yellow; Eastern species .... *nigriceps*
   Scutellum mostly dark; Western species .... *picta*

LOCAL SPECIES.

The following eighteen species have been taken in Northern Virginia at, or in the vicinity of, Falls Church. Of the eighteen, thirteen have been taken in June, two (*Myopa*) only before June, and three only later than June. Almost invariably they occur only on white blossoms; *Myopa* in early spring has been taken on red bud, but prefers amelanchier.

Physocephala tibialis Say. Fairly common, 14 June to 17 Sept.

Physocephala sagittata Say. Falls Church, 17 June to 8 July.

Conops brachyrhynchus Lw. Falls Church, 16 June to 6 July.

Conops xanthostomus Will. Falls Church, 5 July to 8 Sept.

Conops sylvosus Will. Falls Church, 9 May to 15 July.

Myopa vicaria Walk. Falls Church and Great Falls, 15 April to 27 May.

Myopa vesiculosa Say. Falls Church and Great Falls, 10 to 27 April.

Myopa virginica Bks. Falls Church, 15 June to 7 July.

Occemyia abbreviata Loew. Common, 22 May to 31 July.

Occemyia loraria Loew. Common, 14 June to 18 Sept.

Zodion fulvifrons Say. Common, 13 June to 24 Sept.

Zodion perlongum Coq. Falls Church, 6 to 21 Sept.

Zodion sayi Bks. Falls Church, 6 July to 27 Sept.

Zodion nanellum Loew. Two from Falls Church, Great Falls, 16 June, 7 Sept.

Zodion parvum Adams. Three from Glencarlyn, 24 June, 2 July.

Dalmannia nigriceps Loew. Great Falls, Glencarlyn, 5 and 7 June.

Dalmannia vitiosa Coq. Falls Church, Glencarlyn, 14 and 17 June.

Stylogaster neglectus Loew. Falls Church, Great Falls, Glencarlyn, 14 June to 27 July.

THE REFLEX "BLEEDING" OF THE COCCINELLID BEETLE, EPILACHNA BOREALIS.

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INTRODUCTION.

It is a well-known fact among entomologists that when disturbed certain coccinellid and meloid beetles fold the antennæ and legs against the body, eject small drops of liquid from the femoro-tibial articulations and feign death. There has been quite a controversy as to how the liquid is expelled so quickly and as to whether the liquid is blood or is a glandular secretion. Those who believe that the liquid is blood fail to show how it passes through the articular membrane to the exterior, and those who think that the liquid is a glandular secretion do not conclusively prove their view and they fail to explain how such a large quantity of the secretion can be expelled so quickly.

The phenomenon of ejecting liquid from the femoro-tibial articulations has been called "reflex bleeding." The object of the present paper is to show that the phenomenon is a true reflex, but that instead of the liquid being blood, it is a secretion from hypodermal glands and that it passes to the exterior through innumerable tubes opening near and in the articular membrane.

To obtain material for sections, adult beetles that had been kept in the laboratory all summer were mostly used, although two beetles emerged a short time were also used. Most of the sections were cut five microns in thickness, and all of them were stained with Ehrlich's hematoxylin and eosin. In regard to more details concerning the technique, the reader is referred to the writer's work (1915) on "The Olfactory Sense of Coleoptera."

EXAMINATION OF LIVE BEETLES.

When live individuals of *Epilachna borealis* are examined without irritation under a low-power lens, they appear wet. The more the beetles are irritated the wetter their integuments become. The entire chitinous integument is more or less covered with small yellow flakes. On the legs and elytra these flakes are numerous, and they may be easily removed with a needle. Beetles in the field eject small drops of liquid from the femoro-tibial articulations when only slightly irritated, but after they have been handled and kept in captivity for a short time a stronger mechanical stimulus is necessary to cause them to force liquid from the articulations. Beetles kept in confinement four months with plenty of pumkpin leaves and water were tested to ascertain how many drops of liquid a leg is able to expel in rapid succession. A hind leg was able to eject as many as six small drops with only a few seconds intervening between the emission of any two of them. A middle or front leg was not able to eject quite so many drops. Under a low-power lens the liquid seemed to come from the articular membrane and from the extreme proximal end of the tibia. Each time the leg was irritated a much smaller drop was also seen on the first tarsal joint.

To determine the strength of the mechanical stimulus required and the mechanics employed in ejecting the liquid to the exterior, beetles were placed on their backs under a low-power lens. When the distal end of a femur was gently touched with a needle, a muscular contraction instantly folded the tibia against the femur, and a small drop of liquid appeared simultaneously at the articulation. The drop always increased slightly in size after first appearing. A stronger stimulus with the needle was required to bring about the emission of each succeeding drop. The sixth drop, the smallest of all, was produced only by rubbing the entire femur hard with the needle. Legs with the tibiæ folded against the femur can also eject the liquid, but not so easily. Muscular contractions may be noticed in them. Legs held out straight are also able to eject the liquid, but with much difficulty, and muscular contractions are very evident.

The liquid ejected has an amber color and a very offensive odor. It is almost as bitter as quinine and when tasted, a bitter taste lingers in the mouth for almost a half day. It is slightly viscid and dissolves slowly in water. In order to compare it with blood entirely free of any hypodermal glandular secretion, the wings of the same live beetles were cut in two. It will later be shown that the wings do not contain any hypodermal glands, but they are full of blood. Blood from the wings has the same color, the same taste and probably the same odor as the ejected liquid, but the blood is not viscid and it dissolves readily in water and does not sink as quickly as the ejected fluid.

DISTRIBUTION OF HYPODERMAL GLAND PORES.

In order to study the distribution of the pores through which the liquid presumably comes, causing the integument to be wet, several specimens were treated with caustic potash twenty-four hours. When removed from the caustic potash, all the tissues were disintegrated leaving only the chitinous parts. When thoroughly washed with water the chitinous integuments were carefully examined.

Minute pores were observed in the chitin of the thorax, abdomen, legs and elytra. The wings contain none of these pores and the head with its appendages were not examined. A single pore (Figs. 1, 6 and 7, *p*) usually lies near the base of each hair, but sometimes two pores may be seen near the base of a hair. Sometimes a pore lies against the hair socket (Fig. 7, *sk*). When the pores are more numerous than the hairs, they are grouped together and are not associated with the hairs. The pores are most abundant on the legs (Figs. 1–3, *p*). Besides most of the hairs on the legs being associated with pores, four groups of this type of pore lie near the femoro-tibial articulation and these pores are also grouped together on the tarsal joints. For this reason the region around the femoro-tibial articulation (Fig. 1) contains the most pores of any part of the integument. The first tarsal joint (Fig. 2) contains less and the fourth tarsal joint (Fig. 3) is least well supplied with pores. The thorax (Fig. 6) and the dorsal side of the elytron (Fig. 7) are well supplied with pores, but here the pores are associated with the hairs and are never grouped together.

Another type of pore was found. While examining the articular membranes (Fig. 1, *artm*) of the femoro-tibial articulations, many minute pores were seen in them. This is the first time that pores are reported in the articular membrane.

The group of pores (Fig. 1, *a*) always present on either side of the proximal end of the tibia is oval in shape and the chitin containing the pores is lighter in color than the surrounding chitin. In counting the pores in the groups, all the legs of five individuals were used. The number of pores in the groups on the tibæ of the front legs varies from 14 to 25 with 17 as an average; on the tibiæ of the middle legs from 13 to 30 with 20 as an average; on the tibiæ of the hind legs from 18 to 28 with 23 as an average. The general average number of pores in these groups for all three pairs of legs is 20.

The group of pores (Fig. 1, *b*) at the distal end of the femur and near the articular membrane is arranged in a manner more or less like a string of beads (Fig. 4). A group is present on either side of the articular membrane, but both groups on the same femur can never be seen because one of them always lies under a portion of the femur. For this reason the pores in only about a half of these groups were counted. On the front legs the pores vary from 24 to 26 with 25 as an average; on the middle legs from 24 to 37 with 30 as an average; on the hind legs from 29 to 38 with 32 as an average. The general average number of pores in the groups on the femurs of all three pairs of legs is 30.

On account of the opaqueness of the articular membrane and the small size of the pores found in this membrane, these pores can not be counted, but they are estimated as from 200 to 500 for each membrane

Since the four groups of pores near the articular membrane and those in the membrane are the only openings, besides a few olfactory pores (Fig. 1, *olp*) and the pores associated with the hairs, which pass through the chitin at the femoro-tibial articulation where the drop of liquid appears, we must conclude that these pores are the only passages through which the liquid is ejected to the exterior. Counting only the pores in these groups and those in the articular membrane, we see that each tibia has 40 pores, each femur 60 pores, and each articular membrane perhaps 400 pores, making about 500 pores through which the liquid issues. Since all of these pores are so close together the liquid from all of them unites into a drop, while a drop is never seen elsewhere except on the first tarsal joint where there are also many pores near one another.

STRUCTURE.

In the preceding pages it is shown that the liquid ejected passes through pores in and near the articular membrane. In the following pages it shall be determined whether the liquid ejected is blood or a glandular secretion.

1. *External structure.*

When observed under a high-power lens, the pores in the groups and those associated with the hairs appear as very small light spots. In a vertical view each light spot (Fig. 3, *p*) is bordered by a dark circle inside of which appears a transparent spot that is bordered by a much smaller circle. The internal anatomy of a pore (p. 206) shows what these various parts are. In oblique views the inner circles (Figs. 2, 4 and 5) appear as small wedge-shaped figures.

The pores vary considerably in size. All of those on the tibia (Figs. 1 and 5), all of those associated with hairs on the femur (Fig. 1), and those on the thorax (Fig. 6) and elytron (Fig. 7) are of about the same size. Those in the groups on the femur (Fig. 4) are comparatively large, while those on the tarsus (Figs. 2 and 3) are medium in size. Any one of these pores is several times smaller than an olfactory pore (Fig. 1, *olp*). The pores in the articular membrane (Fig. 8, *pl*) are about equal in size to the inner circles of the other type of pore. The tubes connecting with these pores have the same size.

2. *Internal structure.*

Sections through all the foregoing enumerated pores, except those in the articular membrane, show that this type of pore is connected with reservoirs. And furthermore, since both types of pores are the external openings of hypodermal glands, these structures may be designated hypodermal glands with and without reservoirs.

(*a*) *Hypodermal glands with reservoirs.*

There is a great difference in appearance between the hypodermal glands in old adult beetles and those in beetles emerged a short time.

(*1*) *Mature hypodermal glands.*

In sections through this type of gland, that part of the structure to be noticed first is the reservoir (Fig. 9, *r*). It appears as a round or slightly oblong, light-colored cavity. An efferent tube (*e*) runs from the surface of the chitin into the reservoir and ends about one-third the distance from the bottom of the reservoir. A dark-staining, granular substance is usually seen around the end of this tube in the reservoir. It is now easily seen that the diameter of the light spot in a superficial view is equal to the diameter of the reservoir, and that the transparent spot surrounded by a much smaller circle is the same as the outer opening of the efferent tube. This opening is in reality the pore.

Just beneath the reservoir lies the pore canal (*pc*) which is usually narrower than the diameter of the reservoir.

Lying in the hypodermis just beneath the pore canal lies the large gland cell (*glc*). On account of its size and the way the hypodermal wall (Figs. 20 and 21) bulges around it, this cell is much more conspicuous than the hypodermal cells. In fact the walls of the hypodermal cells can not be recognized but their nuclei (Fig. 20, *hnuc*) are distinct. The nuclei of the gland cells (Fig. 9, *nuc*) are larger than those of hypodermal cells. They are usually round while those of the hypodermal cells are oblong. They generally lie in the broader ends of the cells. Their nucleoli (*nucl*) are always distinct. The cytoplasm (*cyt*) is more or less granular. Lying either near the center or in the narrower end of the cell there is a transparent, round area, the ampulla (*am*), which is usually larger than the nucleus. The ampulla appears to contain radial lines, but on account of the small size of the cells, these lines are almost indiscernible. At the center of each ampulla is always distinctly seen the free end of the conducting tube (*c*) whose walls at the free end are darker than elsewhere. Sometimes a dark circle is seen at the center of the ampulla, showing that the conducting tube has been cut in two. This fact shows that the tube is really hollow and is not solid. The conducting tube leads from the center of the ampulla through the pore canal to the reservoir where its walls unite with the walls of the mouth of the reservoir.

The gland cells vary considerably in size. The largest ones (Fig. 18, *glc*) are associated with the groups of pores at the distal end of the femur. Those in the elytra are about as large as those widely distributed in the legs.

The reservoirs and pore canals (Figs. 10 and 11) also vary considerably. The reservoirs in the femur near the articular membrane (Fig. 19) are the largest. The pore canals and conducting tubes depend in length on the thickness of the chitin (Figs. 10 and 11) which varies much.

In order to ascertain if the efferent and conducting tubes are chitinous, fresh material containing the femoro-tibial articulations was treated in caustic potash four hours. A study of the sections made from the material thus treated showed that these tubes are composed of chitin (Fig. 12, *e* and *c*).

(2) Origin of hypodermal glands with reservoirs.

In regard to the formation of the reservoirs and efferent tubes nothing can be said, because they are fully developed when the insect emerges, and no younger stages were preserved in fixing fluids.

When the insect has been emerged an hour, the chitin is about one-third developed. This is seen by comparing Figures 11 and 13. Figure 11 is from an old adult, and Figure 13 is from a beetle emerged one hour. The darker-colored chitin (Figs. 10 and 11, ch_1) is formed before the insect emerges and the lighter-colored chitin (ch_2) is formed after the beetle emerges.

When the insect has been emerged an hour, the gland cells vary in development from undifferentiated hypodermal cells to almost fully developed gland cells. At this stage the hypodermis (Fig. 13, *h*) is comparatively thick and the hypodermal cells (*hc*) appear as dark-staining nuclei without the cell walls being visible. The first stage in the formation of a gland cell may be represented by a large hypodermal cell at the mouth of a reservoir (Fig. 13, *hc*). The second stage is represented by a hypodermal cell that has enlarged sufficiently to cause the hypodermal wall to bulge outward. Its nucleus is now comparatively light in color, its cell wall is discernible, and its cytoplasm is darker than that of the hypodermis. Figure 14, *glc*, represents such a stage.

The third stage in the development is represented by a gland cell that is forming the conducting tube. All the steps during the formation of the conducting tube were not seen, but enough were observed to imagine the full procedure in the development. A gland cell in the second stage of development is round, or slightly oblong. Now it begins to elongate rapidly and one end begins sending out a process. At this step the ampulla appears and the free end of the conducting tube is formed. The conducting tube is formed from the cellular secretion as rapidly as the process of the cell grows in length. Since the tube at this step often appears as a single dark heavy line instead of two parallel lines, it is probably laid down as a rod of secreted substance rather than as a tube, but later it becomes cylindrical. Gland cells with processes (*pr*) of various lengths are shown in Figures 15 to 17. One process (*pr*) shown in Figure 17 has actually entered the mouth of a reservoir. Now it may be imagined that the protoplasm at the tip of the process withdraws and the peripheral end of the tube unites with the walls of the mouth of the reservoir.

By the end of the third stage of development, the gland cells are probably fully developed in size (compare Fig. 16, *glc*, and Figs. 9 and 10, *glc*), but they certainly do not function as gland cells until all the chitin is developed. The thicker the chitin becomes, the longer the pore canals and conducting tubes must be, and the farther the gland cells must migrate into the lumen of the appendage. Up to the time of the fully developed chitin, the gland cells, instead of producing a glandular secretion, produce a chitinous secretion to form the conducting tubes. Perhaps the withdrawal of the protoplasm from the tip of the cell process keeps pace with the lengthening of the pore canal, so that by the time the chitin is fully formed there is no protoplasm surrounding the conducting tube. Now, instead of the gland cells standing more or less vertically to the chitin, they lie parallel to the chitin, and the conducting tubes no longer enter the tips of the narrower ends of the cells, but they enter the sides of the cells usually about midway between the two ends.

(*b*) *Hypodermal glands without reservoirs.*

In a section through the articular membrane (Fig. 18, *artm*), may be seen one or more small tubes. These are the conducting tubes (c_1) observed in chitinous preparations as shown in Figure 8. They are so small and so transparent that they were not noticed until after this piece of work was almost completed. For this reason, it is not surprising to know that other investigators have overlooked them. They have no reservoirs. Each one pierces the chitin and terminates (p_1) on the surface of the flexible and comparatively thin articular membrane.

A layer of peculiar hypodermal cells had been noticed beneath the articular membrane for some time before the conducting tubes had been observed, but these cells were not given any particular attention until the conducting tubes had been discovered. A careful study of these cells (Fig. 18, glc_1) under the highest lenses soon showed that they are gland cells like the ones already described except they are several times smaller. Since they are so small their internal structures can not be studied critically. A conspicuous nucleus is always present, but the ampulla is generally indiscernible and no tubes were seen running into the cells, although it is common to see the free ends of the tubes among the cells. That no tubes were seen entering the cells is easily explained by supposing that they were pulled out of the cells by the hypodermis withdrawing from the chitin during the fixation. The injury produced by the tubes being pulled out of the cells is certainly the cause of the ampullæ being rarely seen. While examining live gland cells in the honey bee, the writer (1914) found that the slightest injury to the cells caused the ampullæ to disappear.

At certain places the gland cells (Fig. 21, glc_1) lie bead-like in the hypodermis, causing the hypodermal wall to bulge out around each of them, while at other places they lie in groups (Figs. 18, 19 and 21 glc_1) among the cells belonging to the other type of hypodermal glands.

(1) *Origin of hypodermal glands without reservoirs.*

Since no material of pupæ was prepared, little can be said about the origin of these glands, because the conducting tubes are fully developed and the gland cells are being rapidly formed when the insect emerges. When the insect has been emerged an hour, large hypodermal nuclei (Fig. 19, *hnuc*) may be seen beneath the articular membrane, and many small cells, presumably gland cells (glc_1), lie in and below the hypodermis among larger gland cells (*glc*).

There is no doubt that these gland cells are modified hypodermal cells, but since the conducting tubes pierce the entire thickness of the chitin, they must have been formed simultaneously with the chitin. The conducting tubes belonging to hypodermal glands of the same type in the honey bee are formed as follows: Just before the hypodermal cells begin secreting the chitin, some of them begin sending out processes into the lumen of the abdomen. At the same time other hypodermal cells migrate into the lumen and the processes sent into the lumen unite with the cells that have migrated inward. Each process forms a chitinous tube which runs from the ampulla to the surface of the chitin. By the time the chitin is fully developed, the gland cells are also fully developed, the protoplasm in the processes has been withdrawn from around the tubes, and the tubes are firmly embedded in the chitin.

HOW REFLEX "BLEEDING" IS ACCOMPLISHED.

The lumen in the extreme proximal end of the tibia is divided into two almost equal chambers (Fig. 20, *bs*) by a membrane (h_1) extending across the leg. In structure and general appearance this membrane resembles the hypodermis with which it unites on each side of the leg. In that chamber containing the nerve (*n*) and trachea (*tr*) lie only a few scattered gland cells and only a small amount of blood may be seen in it. The other chamber is full of blood and it is the one that contains all the gland cells (*glc*) belonging to the two groups of pores found on the tibia. No muscles are seen in the tibia at this place.

The lumen in the extreme distal end of the femur is likewise divided into two chambers by a membrane. In sections passing through the articulation, may be seen muscle fibers (Fig. 21, *m*) at the extreme distal end of the femur, tracheal branches (*tr*) running to the gland cells (*glc*), and a nerve (*n*) running through the center of the articulation. All the space not filled by the preceding structures may be called blood sinuses (*bs*).

Under ordinary conditions in the natural environments of the beetles all the reservoirs, conducting tubes and ampullæ are possibly kept constantly full of the glandular secretion. It is reasonable to think that all parts of the cytoplasm of the gland cells are slowly and constantly producing a secretion that flows into the ampullæ from which it gradually passes through the conducting tubes to the reservoirs, if present, from whence it passes through the efferent tubes to the exterior. On the surface of the chitin the secretion forms a small circular film around the exit of each pore. Since this secretion is quite volatile and has an offensive odor, perhaps no further discharge of the secretion is necessary to guard off most of the enemies of this insect. During the constant discharge of this secretion no reflex is called into play.

Since a pore lies near the base of each hair, and as many of these hairs are innervated, a correlation between each tactile hair and the pore near it might at once be suspected. To imagine that the pore lies near the hair for mere protection is not sufficient correlation, because the innervation of the hair would not be needed, if only the protection of the pore is considered. A little speculation, therefore, may not be out of place. When a tactile hair is touched, its sense cell is stimulated. Since the sense cells lie near and sometimes against the gland cells, the former may in some unknown way stimulate the latter. If such should be the case, then the gland cells would begin vigorously at once to produce more secretion. And as a result much more liquid would be discharged than ordinarily. If such a relation exists between the gland cells and tactile hairs, the writer can think of no simple reflex better adapted for protecting the insect.

Considering the discharge of liquid at the femoro-tibial articulation, there is no question about the reflex, but whether the stimulus is brought about by pressure on the chitin or by a stimulation of several sense cells belonging to tactile hairs, is an open question. Since only a slight mechanical irritation at the distal end of the femur is required to cause a discharge of the secretion, it is more reasonable to think that the stimulation is brought about by the tactile hairs than by the pressure on the chitin. As soon as the tactile hairs are touched, the muscles contract folding the tibia against the femur and forcing the blood into the chamber containing the gland cells. At once the gland cells are put under a high blood pressure which immediately stimulates them. Instantaneously they discharge all the secretion in their ampullæ causing the secretion in the reservoirs to be shot to the exterior. Now the gland cells without reservoirs play their part by immediately increasing the size of the drop of discharged liquid. Causing drops to be discharged may be continued until the gland cells become exhausted which really occurs after the fifth or sixth drop has been expelled. Each drop is smaller and is discharged less quickly than the preceding one. This shows that the supply of liquid is limited from the beginning, and that a little more time is required for producing each succeeding drop than the preceding one, but if the liquid were blood such would not be the case. It would seem that the liquid secreted under such an emergency would not be exactly the same in composition as that which is produced when the cells are not overworked, but under normal conditions it is perhaps never necessary for these insects to exhaust this glandular secretion.

From the preceding it is evident that the phenomenon of ejecting liquid from the femoro-tibial articulation is a true reflex, but instead of the liquid being blood, it is a hypodermal glandular secretion, instantaneously discharged to the exterior under a high blood pressure which is caused by a muscular contraction, forcing the blood into a specially devised chamber containing the gland cells. It is, therefore, seen that the membrane extending across the lumen of the leg plays an all-important part in the discharge of the secretion, because if it were not present the blood would occupy too much space and could not be put under a sufficiently high pressure to stimulate all the gland cells simultaneously. Furthermore, since the nerve and trachea lie in the chamber containing only a few scattered gland cells, this may also be a device for protecting these structures against a high blood pressure.

FUNCTION OF THE HYPODERMAL GLANDULAR SECRETION.

On account of the bitter taste, the high volatility and the offensive odor of this secretion, there is no doubt that its primary function is that of protection. Since we know very little about the ability of the lower animals to distinguish colors, we can not attribute any protecting significance to the color of this secretion, chiefly because the bright amber color is noticed by a person only when drops are ejected from the femoro-tibial articulations. Since these drops are so inconspicuous, it is doubtful whether they are ever seen by an enemy even as large as a bird. Nevertheless, it is quite probable that the amber color is associated with the taste and odor of the secretion.

If the bitter taste of the secretion serves as a means for protecting the insect, it must be granted that the animal seizing the insect can taste and that the secretion in stimulating the gustatory organs of the enemy causes an "unpleasant" sensation. We are certainly safe in saying that the vertebrate enemies (particularly birds) of this insect experience an offensive gustatory sensation when they attempt to eat these beetles. To say that such a sensation is experienced by its insect enemies can not be emphasized, because it has never been conclusively proved that insects can taste.

Since we know that insects as a rule have an acute sense of smell and that the higher animals are also endowed with an olfactory sense, we are safe in assuming that the offensive odor of the secretion is sufficient in most cases to guard off the enemies of this insect. This statement is supported by the fact that most of the common, strong odors, whether pleasant or unpleasant to us, act as repellents to insects.

The taste, volatility and odor of the secretion seem to be due to a peculiar principle called cantharidine, which is a volatile, acrid, bitter solid, crystallizing into four-sided prisms. It is thus seen why the liquid evaporates so quickly when ejected, leaving yellow flakes on the integument.

A few investigators have performed many experiments with various warm and cold-blooded animals by feeding them some of the secretion. De Bono (1889) used many insects, frogs, toads, guinea pigs and coyotes. He found that the secretion from *Timarcha pimeliodes* has a manifest action on the heart of warm and cold-blooded animals, and that it has an injurious effect on *Musca communis*, *Sarcophago carnaria*, although little or no injurious effect on other insects. Lutz (1895) remarks that the secretion from the same insect may kill flies within a few minutes and is poisonous for warm and cold-blooded animals. Porta (1903) fed the secretion from *Coccinella 7-punctata* to various animals. He says that the liquid exercises a poisonous influence upon the organism of both warm and cold-blooded animals, and his experiments show that it is injurious to the brain. He found, however, that it does not exercise any influence upon insects. For *Coccinella* he thinks that the secretion probably serves as a means of defense by the odor which is offensive to other insects and perhaps this yellowish liquid indicates to them a harmful substance.

The odor of the secreted liquid, besides serving as a means of defense, probably also serves as a means for individual and sexual recognition. The secretion of a given species perhaps emits a specific odor by means of which the different individuals and sexes of that species recognize one another.

DISCUSSION.

Lacordaire (1838) was one of the first investigators to describe the phenomenon of ejecting liquid from various parts of the body of certain insects. He says that when *Dytiscus* and *Gyrinus* are picked up, they emit through the articulations between the head, thorax and abdomen a milky and fetid fluid. *Meloe* emits from the articulations of the legs a yellowish-orange liquid whose odor is not disagreeable. Coccinellidæ and Chrysomelidæ emit an analogous liquid at the same places, but it has a different odor and is quite strong.

The ejection of a liquid from the articulations of the rudimentary wings of certain Orthoptera has been studied by Cuenot (1896a) and others.

Izquierdo (1896) says that liquids discharged by insects as a means of defense may be divided into three groups: (1) Those from organs which are furnished with glands. Such organs are found in all the families of insects and their exits may be found in the thorax, abdomen, at the anus or in the last portion of the intestine; (2) liquids which are discharged from the femoro-tibial articulations; and (3) liquids that are discharged from the mouth.

From the preceding it is seen that liquids may be discharged from various parts of the body of insects and that this phenomenon is not restricted solely to beetles.

Leydig (1859) was the first to make sections through the femoro-tibial articulations of *Timarcha*, *Coccinella* and *Meloe*. He thinks that the discharged liquid is blood for the following reasons: (1) No gland cells nor glandular apparatus of any kind were recognized; (2) the discharged liquid and blood have the same color; and (3) the discharged liquid contains presumably blood cells. He admits that this view is not well founded because he could not find any openings in the articular membrane through which the blood could pass.

Cuenot (1890) says that the discharged liquid from the legs of the meloid beetles, *Cantharis*, *Meloe*, *Mylabris* and *Cerocoma*, is completely odorless, but it is slightly poisonous. He thinks that this liquid is blood, although he did not study sections passing through the articulations. The same author (1894) states that when one touches *Timarcha*, *Adimonia*, *Coccinella* or *Meloe*, the beetles at once feign death. They fold the legs and antennæ under their bodies, fall to the ground and for a longer or shorter time assume a perfectly inactive attitude destined to deceive their enemies. At the moment when the insects roll on the ground, drops of a slightly viscid liquid are ejected from the mouths of *Timarcha* and *Adimonia*, but from the femoro-tibial articulations of the coccinellids and meloids. This liquid is yellowish or reddish in color. The discharged liquid of *Coccinella* has a strong and very disagreeable odor, and that of *Timarcha* is odorless, but has a persistent and astringent taste. He proved by experiments that this liquid is for defense.

Cuenot (1896b) summarizes his investigations by saying that *Timarcha*, *Galeruca*, *Megalopus*, coccinellids and meloids among the Coleoptera, and *Eugaster* and *Ephippiger* among the Orthoptera possess the phenomenon of reflex bleeding. When disturbed they feign death and eject drops of blood from the mouth, femoro-tibial articulations and from the articulations of the first pair of wings. In all these species the blood comprises toxic, caustic or repulsive products. It is an important means of defense against lizards and batrachians.

Lutz (1895) asserts that in the Coccinellidæ, blood coming from the distal end of the femur issues through a slit on either side of the articular membrane which surrounds the chitinous rods (Selane) to which the extensors of the tibia are attached. The blood exudes by a forced contraction of the abdomen and by the flexors of the tibia, and it is a voluntary act. It is a means of defense because the blood is actually quite repulsive to insectivorous animals. In *Timarcha*, *Meloe*, etc., as in the coccinellids, the device of ejecting blood from the femoro-tibial articulations is to permit the blood to escape from the legs rather than through the mouth.

Packard (1895) states that many beetles, such as the oil beetles *Meloe*, *Cantharis* and *Lytta*, emit drops of blood from the femoro-tibial articulations as a means of defense. The cantharadine produced by these insects is formed in the blood and in the genital organs. It is so extremely caustic that scavenger insects feeding upon the dead bodies of these beetles leave untouched the parts containing cantharadine. Coccinellids are also protected by a yellow mucilaginous and disagreeable fluid which is emitted from the sides of the thorax.

Of those who advocate the view that the discharged liquid is blood, Leydig is the only one who has studied sections passing through the femoro-tibial articulations. And even he admits that his view is not well founded, because he failed to find any openings at these articulations. Lutz has certainly mistaken some other structure for slits. Perhaps he has seen the olfactory pores which often lie where his supposed slits were observed.

The following authors believe that the discharged liquid is a glandular secretion.

Magretti (1881) imagines that the discharged liquid from *Meloe* is secreted by gland cells in the legs.

Beauregard (1885) saw a layer of large hypodermal cells beneath the chitin in sections through the articulations of the legs of *Meloe*. He imagines that these large cells are gland cells.

De Bono (1889) believes that the discharged liquid from *Timarcha* is a glandular secretion.

Porta (1903) says that the discharge of the secretion from *Coccinella*, *Timarcha* and *Meloe* is caused by a reflex phenomenon brought about by any excitement. The liquid is secreted by a glandular follicle in the reticulum formed from the fibers of connective tissue, situated in the wall of the middle intestine. The liquid has an acrid reaction, and it is perhaps only a bile secretion. He gives three reasons why this liquid is not blood: (1) It is inadmissible that insects should constantly pass such an important fluid; (2) after a prolonged excitation the liquid ceases to exude; and (3) it has an acrid reaction while we know that blood in all animals has an alkaline reaction. He fails to explain how this secretion reaches the exterior from where it is produced.

Berlese (1909) seems to think that the discharged liquid from *Meloe* is a mixture of blood and a secretion from hypodermal glands. In a diagram showing the anatomy of the leg at the femoro-tibial articulation, he figures a receptacle for containing the blood and shows how the blood is ejected through an aperture at this place in the leg. He also shows unicellular glands lying just beneath the hypodermis on both sides of the articulation. Each gland cell is almost spherical, has a conspicuous nucleus and a central vesicle, the ampulla, from which runs the efferent tube through the hypodermis and chitin to the exterior. These gland cells are like the ones without reservoirs described by the present writer.

Of those who believe that the discharged liquid is a glandular secretion, only Beauregard and Berlese have studied sections passing through the femoro-tibial articulations. Berlese is the only one who has actually found gland cells at this place in the legs. His receptacle for containing the blood is perhaps the same as the special chamber described by the present writer. Since Leydig did not see an aperture in the articular membranes of *Timarcha*, *Coccinella* and *Meloe*, and as the articular membrane of *Epilachna* does not contain any aperture, it would seem that the aperture described by Berlese was only an artificial opening in the chitin made when the material was sectioned. The present writer has examined the femoro-tibial articulations of the meloid beetles, *Cysteodemus armatus* and *Epicauta pennsylvanica.* The specimens were first treated with caustic potash and then the chitinous integuments were bleached with chlorine gas. No apertures were seen in or near the articular membranes, but innumerable, almost transparent, minute tubes were observed in and around the articular membranes. Minute gland pores were also seen widely distributed over the entire integument as described for *Epilachna.*

A survey of the literature pertaining to hypodermal glands shows that these glands vary much in structure.

As far as ascertained by the writer, Hoffbauer (1892) is the only one who has described hypodermal glands having reservoirs in the chitin. These are found in the elytra of *Tetropium* and *Halyzia.* The reservoir belonging to the gland in the former species is nothing more than a much expanded efferent canal through which the secretion passes to the exterior. The reservoir in the latter species is similar to that in *Epilachna*, except its efferent tube is a wide canal. In *Halyzia* the elongated cells stand vertically to the chitin with their narrower ends uniting with the mouths of the reservoirs. These gland cells have no ampullæ nor conducting tubes.

Tower (1903) found simple and compound hypodermal glands widely distributed in the elytra of *Leptinotarsa*, *Prionus* and *Orthosoma*, but they do not have ampullæ, conducting tubes nor chitinous reservoirs. These gland cells stand more or less vertically to the chitin with their extremely attenuated peripheral ends in contact with the mouths of minute pores.

Casper (1913) found hypodermal glands widely distributed over the entire body surface and appendages of *Dytiscus marginalis.* In structure they are similar to the ones without reservoirs described in this paper.

Lehr (1914) found hypodermal glands widely distributed in the elytra and wings of *Dytiscus marginalis.* In structure they are similar to those without reservoirs described by the present writer, except they are much larger.

SUMMARY.

Hypodermal gland pores are widely distributed over the entire integument of *Epilachna borealis.* Usually one, but sometimes two pores, lie near the base of almost every hair. Besides lying near the bases of the hairs, the pores on the tarsi and around the femoro-tibial articulations lie in groups. Two groups are located at the extreme proximal end of the tibia and two at the distal end of the femur around the articular membrane. All four groups contain 100 pores as an average. The articular membrane contains about 400 pores of another type.

These beetles always appear wet, and the more they are irritated the wetter they become. The wet appearance is caused by a hypodermal glandular secretion passing to the exterior through the pores. When irritated the beetles eject small drops of the amber-colored secretion from the femoro-tibial articulations through the four groups of pores near the articular membrane and those in the membrane. The discharge of the secretion is accomplished by putting the gland cells under a high blood pressure. This is made possible by a muscular contraction in the femur whereby the blood is forced into a specially devised chamber containing the gland cells which belong to the pores in and near the femoro-tibial articulation.

The gland cells are of two types. Those with reservoirs are several times larger than those without reservoirs. The former are widely distributed throughout the entire insect, while the latter is found only under the articular membrane of the femoro-tibial articulation. In other respects the two types are alike. Each gland cell has an ampulla and a conducting tube which either runs from the ampulla to the reservoir in the chitin or from the ampulla to the surface of the articular membrane. An efferent tube leads from the reservoir to the surface of the chitin.

The glandular secretion is bitter and has an offensive odor. Its chief purpose is that of protection, but it probably also aids the beetles in recognizing the different individuals and sexes of the same species.

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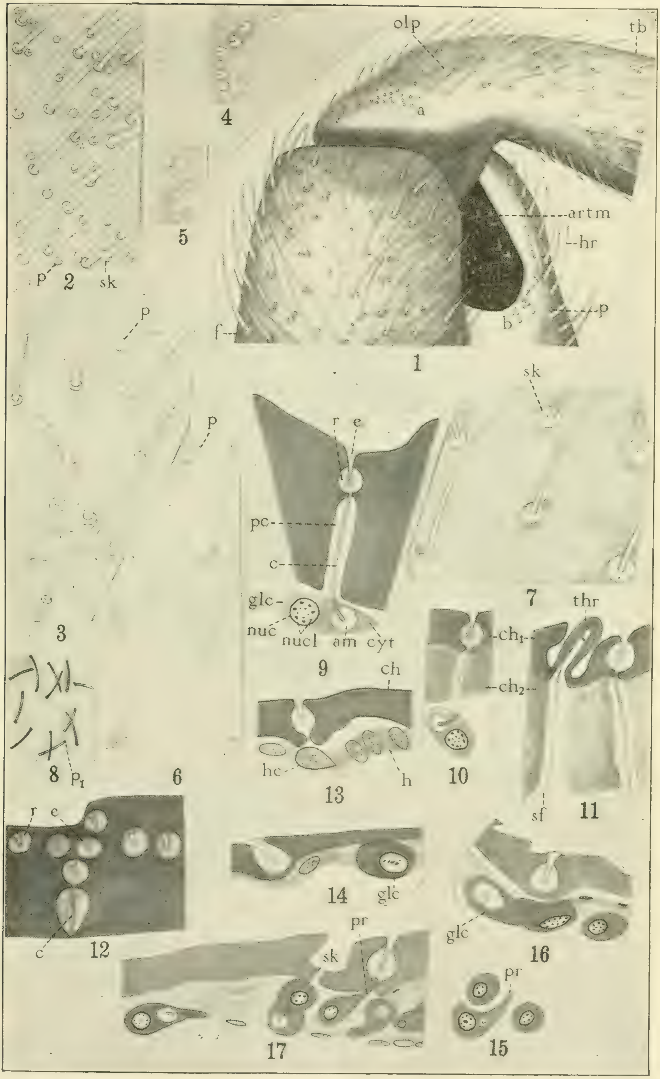
EXPLANATION OF PLATES X AND XI.

All figures except diagram 21 are from camera lucida drawings made at the base of the microscope. The figures are enlarged as follows: 1, × 78; 2 to 7, × 280; 8 to 19, × 875; 20, × 350.

ABBREVIATIONS.

a—group *a* of pores on proximal end of tibia.
am—ampulla.
artm—articular membrane.
b—group *b* of pores on distal end of femur.
bs—blood sinus.
c—conducting tube of gland with reservoir.
c_1—conducting tube of gland without reservoir.
ch—chitin of beetle recently emerged.
ch_1—chitin formed before beetle emerges.
ch_2—chitin formed after beetle emerges.
ct—connective tissue.
cyt—cytoplasm.
e—efferent tube.
f—femur.
glc—gland cell with reservoir.
glc_1—gland cell without reservoir.
h—hypodermis.
h_1—membrane dividing lumen of leg into two chambers.
hc—hypodermal cell.
hnuc—hypodermal nucleus.
hr—hair.
m—muscle fiber.
n—nerve.
nuc—nucleus of gland cell.
nucl—nucleoli of gland cell.
olp—olfactory pore.
p—pore with reservoir.
p_1—pore without reservoir.
pc—pore canal.
pr—process of young gland cell.
r—reservoir.
sc—sense cell.
sf—sense fiber.
sk—socket of hair.
tb—tibia.
thr—tactile hair.
tr—trachea.

Figures 1 to 8 inclusive are superficial views of external ends of hypodermal gland pores of *Epilachna borealis*.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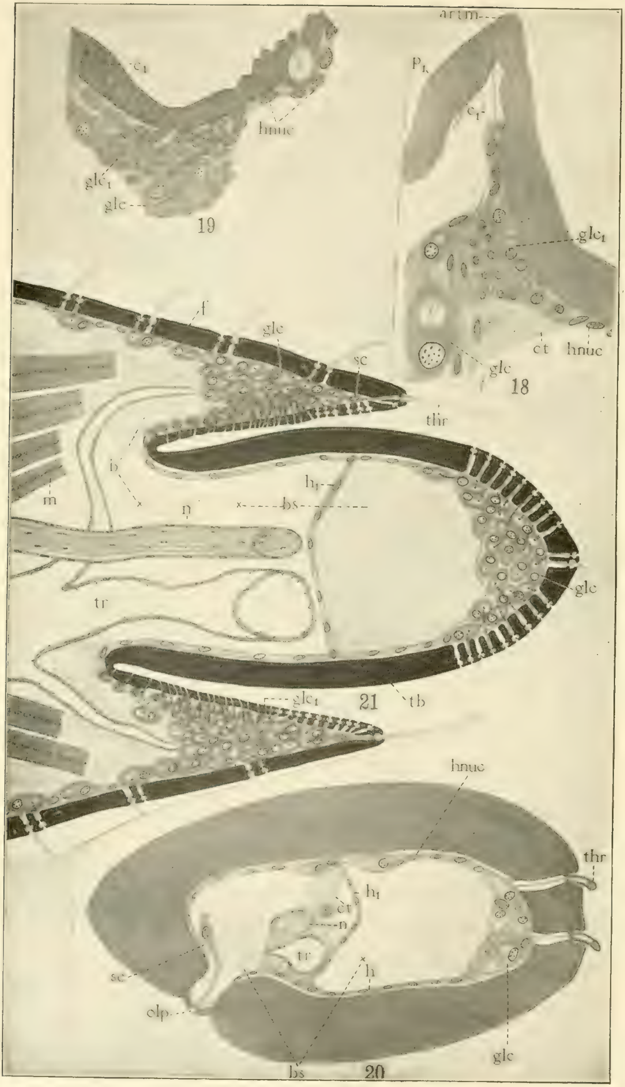
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PLATE X.

Fig. 1. Femoro-tibial articulation of hind leg, showing groups *a* and *b* of hypodermal gland pores, 3 olfactory pores (*olp*), a hypodermal gland pore (*p*) at base of each hair, and articular membrane (*artm*) containing hypodermal gland pores (represented by white dots).
Fig. 2. Hairs and pores on first tarsal joint. Oblique view.
Fig. 3. Hairs and pores on fourth tarsal joint.
Fig. 4. Nine pores from group *b* on femur. Oblique view.
Fig. 5. Nine pores from group *a* on tibia. Slightly oblique view.
Fig. 6. Hairs and pores from tergum of prothorax.
Fig. 7. Hairs and pores from elytron, near base.
Fig. 8. Chitinous tubes connected with pores, seen by looking through articular chitin.
Figs. 9 to 12 inclusive are cross sections, showing structure of hypodermal glands having reservoirs in old *Epilachna borealis*.
Figs. 9 and 10. Complete hypodermal gland cells, showing the nucleus (*nuc*), nucleoli (*nucl*), cytoplasm (*cyt*), ampulla (*am*), conducting tube (*c*), pore canal (*pc*), reservoir (*r*), and efferent tube (*e*). Fig. 9 is from thick portion of outer margin of elytron, and Fig. 10 is from proximal end of tibia.
Fig. 11. Gland pore and tactile hair (*thr*) pore from distal end of femur.
Fig. 12. Oblique superficial section through tibia, treated with caustic potash 4 hours, showing that efferent tubes (*e*) and conducting tubes (*c*) are chitinous.

Figs. 13 to 17 inclusive are cross sections, showing origin of gland cells and conducting tubes of type having reservoirs in recently emerged beetles.

Fig. 13. Four hypodermal cells, one of which (*hc*) is about ready to change into a gland cell.
Fig. 14. Two hypodermal cells, one of which (*glc*) is now enlarged into a gland cell.
Fig. 15. Three young gland cells, one of which is sending out a process (*pr*) to form conducting tube. Figs. 14 to 16 are from a beetle emerged 1 hour.
Fig. 16. Three young gland cells from thick portion of elytron. One of these (*glc*) seems fully developed.
Fig. 17. Young gland cells from proximal end of tibia sending out processes (*pr*) to form conducting tubes. Figs. 17 and 18 are from beetles emerged 24 hours.

Figs. 18 and 19 are cross sections through articular membranes, showing type of glands without reservoirs.

Fig. 18. Conducting tubes (c_1) and gland cells (glc_1) without reservoirs, and 2 gland cells (*glc*) belonging to type having reservoirs from an old beetle.
Fig. 19. Origin of gland cells (glc_1) without reservoirs from hypodermal cells (*hnuc*). Also conducting tubes (c_1) and 2 gland cells (*glc*) with reservoirs from beetle emerged 1 hour.
Fig. 20. Cross section through extreme proximal end of tibia of hind leg, showing anatomy of leg, including tactile hairs (*thr*), olfactory pore (*olp*), gland cells (*glc*), membrane (h_1) dividing lumen of leg into two chambers, blood sinuses (*bs*), etc. The section is 5 microns thick and is from a beetle that had been kept in the laboratory all summer.
Fig. 21. Diagram of a section through femoro-tibial articulation, showing anatomy of leg at this place, including gland cells (*glc*) belonging to the two groups of pores on tibia (*tb*), gland cells belonging to the two groups on femur (*f*), and gland cells (glc_1) without reservoirs, etc. The femur (*f*) is cut longitudinally, but the tibia (*tb*) is cut across obliquely.

HOW GASES ENTER INSECTS.

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INTRODUCTION.

Few experiments have been performed to show how insects take in various gases, whether the gas enters through the spiracles alone, through other openings in the chitin, or even through the chitin. Schafer* has performed a few experiments in which he placed insects in the gas hydrogen sulphide until nearly dead, when they were removed and a warm solution of lead acetate was injected into their bodies by means of a fine hypodermic needle. A black precipitate of lead sulphide showed where the gas had penetrated. In these experiments only larger insects such as white grubs could be successfully used.

Chitin as a rule is rather an impermeable substance and the results in the larger insects showed that the gas had entered through the spiracles. The question arises, Do the smaller insects such as mealy bugs, white fly, soft scales, etc., which have a much thinner layer of chitin depend alone upon their spiracles for the penetration of gases into their bodies? After trying several different agents, it was found that osmic acid vapor could be used as a gas on the insects and would darken the tissues where it entered the insect.

METHOD.

The insect to be studied was placed in a small vial in its natural position on the leaf or stem and the vial suspended in a large bottle containing crystals of osmic acid. The bottle was then stoppered and placed under a bell-jar to prevent a leakage of the gas into the room. The insects remained in the gas for various periods of time, depending upon the insects, after which they were removed, placed in alcohol, and through xylene, finally being mounted in balsam for study.

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*Michigan Agricultural Experiment Station, Technical Bulletin, No. 11, July, 1911, pp. 16.

RESULTS.

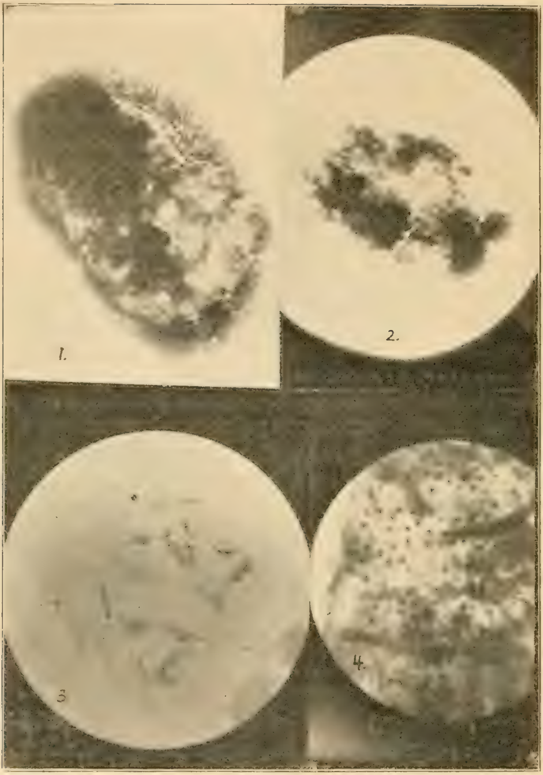
White grubs or the larvæ of wood-borers, showed a blackened area about the spiracles only. Too long an exposure to the vapor causes a uniform blackening of the chitin. Mealy bugs exposed for two to four hours showed a black area around each spiracle, and in addition a black area around the anus, extending up the alimentary canal. The anal lobes which contain many wax glands were also blackened, showing that the gas had entered the wax pores. The wax of the mealy bug was not blackened by the treatment. This is of particular interest, as the mealy bug contains only two pairs of spiracles located near the anterior end of the body. Contrasted with the mealy bug, one finds that the immature stages of the white fly, which is well-protected by a wax coat, only shows a penetration of the gas through the spiracles. The white fly has four pairs of spiracles evenly distributed, one pair being located near the anus.

Spraying plants infested with mealy bugs with a weak soap solution to remove the wax greatly increases the ease with which these insects can be killed by hydrocyanic gas fumigation, while little effect is noticed in its efficiency for white fly.

A species of soft scale, Coccus sp., showed penetration through the spiracles, the anus and also the wax glands scattered about the body. Aphids show the spiracles marked, while some osmic acid seems to enter at the nectaries.

CONCLUSION.

These few experiments show that gases can penetrate through other parts of the body than the spiracles. It seems, however, that very thin chitin is impermeable to osmic acid. Even the vapor of osmic acid, however, is not a good penetrating agent. Oxygen and probably other gases, particularly hydrocyanic acid, which is extremely soluble in water has greater penetration and may even penetrate through thin layers of chitin.



William Moore

EXPLANATION OF PLATE X.

1. Photomicrograph of soft scale, *Coccus* sp., after treatment with osmic acid.
2. Photomicrograph of mealy bug after treatment with osmic acid.
3. Photomicrograph of the anterior portion of immature white fly, showing penetration of osmic acid through the spiracles and along the trachea.
4. A portion of the soft scale, showing wax glands with dots caused by osmic acid.

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THE SLEEP OF INSECTS; AN ECOLOGICAL STUDY.

By Phil Rau and Nellie Rau,
St. Louis, Mo.

An object in motion always attracts the attention of children, young and old; a butterfly flitting from blossom to blossom, a locust jumping before one in the dusty road, a bee rummaging in a flower, all arouse one's interest. But naturalists, like children, cease to pay attention to insects when the latter cease their activity. Thus the interesting problem of when, where and how insects sleep has been all but neglected.

The claim of this problem upon our attention is undeniable when we consider the importance of the period of recuperation in the life of all of the members of the organic world. The sleep of plants, or even the sleep of cotyledons, has been made into charming classics by Darwin and others; how much more interesting ought to be the sleep of animate objects.

The records of this phase of insect life are meagre and isolated, and are only incidental observations. The only purposeful study on the sleep of insects has been done by Fiebrig. This excellent paper is unique in that it deals with the physiological condition of insects during sleep, whereas the other observations and the present study are of an ecological nature.

Our observations were made entirely in the field, sometimes after dark with an acetylene lamp, but more frequently between twilight and darkness. The latter method yielded the more attractive results since the behavior could be noted when they were preparing to retire, while in the former one could learn but little more than the position of the insect in relation to its surroundings when already asleep. A few early morning trips afield were very productive.

WASPS.

Chalybion cæruleum Linne.

A congregation of about thirty of these steel-blue wasps was discovered on the under side of an overhanging rock on the bluffs overlooking the Meramec during July, 1908. It was about 10:30 o'clock in the morning and very dark, due to an approaching storm. It was puzzling to see these wasps, usually of solitary habit, all huddled together in a very small space. They were inactive but alert enough that when an attempt was made to take them they all flew away, but soon returned to the same spot. Three times they thus persistently returned to the identical spot when disturbed. The mud nests of this species are usually situated in a sufficiently sheltered place that it is not necessary for the wasp to seek shelter elsewhere; hence there must be some other reason for each one leaving her solitary nest and all coming together with one accord and seeking the appointed meeting-ground and the company of others. There were many other sheltered nooks among the rocks, but no isolated wasps were in them; this leads one to believe that this assemblage was not due to mere accident.

In 1913, I had another opportunity to study these wasps at Lake View, Kansas, and the results of these observations proved that gregariousness in a modified form does occur in this species. This wasp is not gregarious as is the cockroach, spending almost every hour of its life in the community of others, but in a more anthropomorphic sense. Our nervous little blue wasp only after a day's hard toil of gathering mud and constructing her nest of it mouthful by mouthful, of hunting and paralyzing and carrying home a supply of spiders, at the close of day leaves her work and seeks the chosen spot, there to enjoy the company of other workers who have gathered there likewise to spend the night. The males were also there in numbers equal to the females, but how or where these shiftless fellows spent the day, no one knows.

On July 2, at 7:45 a. m., a number of these blue wasps were found assembled on the ceiling of an open cow-shed. The wasps here had collected in two groups about four inches apart, and a few individuals dotted the intervening space; during the next few minutes they flew away one by one to their day's business after having spent the night there. I watched the spot during the day but none of them returned; at dusk however, they began to arrive, and lo and behold! they settled on the same spot and collected in two groups similar to those of the morning.

I waited until almost dark, and when they were fast asleep I removed about half of them with the forceps to ascertain if both sexes commingled. The twenty insects which I took were 9 males and 11 females. In attempting to take these wasps earlier in the evening when they were not fully asleep, I found them to be more than usually nervous and ever ready to fly away. Sometimes when an attempt was made to take one, simultaneously as if by magic all flew away, but when they were asleep the task was easy; sometimes one grasp with the forceps brought down three insects. Close observation showed that none were in copulo.

I resumed these observations when I again came to the farm six weeks later. I then found a much larger congregation on the same ceiling and the identical spot; they were probably the ones I had left and many newcomers. There were a hundred or more crowded into an area of less than one square foot, and again I noticed that while it was yet slightly light my gentlest approach would invariably start them to flight simultaneously as if by signal, and I sometimes even wondered if they had not a sentinel on watch. When these wasps are engrossed in building or provisioning their nests one can observe them quite closely without arousing such a reaction. On this particular evening they were disturbed three times and each time they left simultaneously, but invariably they returned one at a time.

Careful examinations at various times have convinced me that mating does not occur during these meetings, although both sexes are always present, usually in equal numbers. I have never been able to detect any evidence of their mating in the evening or morning, and during the hours of darkness they are in such deep sleep that they are dead to all the world about them. Possibly they meet here preparatory to the marriage flight when the sun is high.

One morning we took about fifty of these wasps from the ceiling and marked them with paint, to see whether the same individuals returned night after night, and for how long a period. During the next three nights from six to nine marked insects could be distinguished in the clusters. Even so small a proportion as this demonstrates that the same wasps returned to the appointed spot night after night. Doubtless some of the wasps succeeded in cleaning off the marks, and others were probably mortally injured by the forceps or the paint. It was interesting to see that on the first and second night thereafter most of the marked insects took their position on the ceiling to the rear of the joist, a position never taken before (the sacred spot was just in front of this joist), but on the third night even these had become fearless again and joined the main body. Two weeks later, upon leaving the farm, I picked up 38 of the insects to take with me, (19 males and 19 females) and to my great surprise two of them still retained markings of sufficient distinctness to identify them, thereby proving that at least a part of the insects faithfully returned to the roosting place for two weeks or more.

What explanation can there be for this diversity between the habits of *C. caeruleum* and of *Pelopœus caementarium*, a wasp very similar, who builds nests which are indistinguishable from those of this species? The one is gregarious at night, and the other, after a day's hard labor of exactly the same kind, seeks solitary shelter under some friendly leaf.

This discovery that the blue wasps congregate at night solves the problem of the group under the rock at Meramec Highlands. When the sky became clouded and darkness fell over the earth at mid-day, this afforded sufficient stimulus to prompt the wasps to hie them to bed, in much the same way as darkness affects poultry.

This work suggests many interesting problems: Is this gregarious habit at night an incipient stage to higher development and socialization, or is this condition a vestige from the time when they or their ancestors were social insects?

Since the female alone works hard at nest-building and provisioning, what becomes of the male during the day, where does he go, and how does he spend his time?

Since it seems that mating does not occur during the night and since the female is busy at her work during the day, when and where does mating occur, and is more than one union necessary?

Has this gregarious habit been acquired as a means of protection and mutual guarding, since the sting of this insect is very mild?

Sceliphron (Pelopœus) **cæmentarium.**

Even in localities where *S. caementarium*, the common mud-daubers, occur in abundance, I have only once been able to discover how they sleep and where they spend their nights, since they do not remain on their nests after working hours. During the summer of 1915, from June 1 to 5, two mud-daubers returned each night to two distinct elderberry bushes, and while they did not always take the same branch they usually occupied each the same plant. Night after night I watched them until nearly dark, and found that as it became darker they grew quiet and so remained, resting on the foliage in an easy but not exaggerated posture.

One day late in May it suddenly became cloudy and quite dark at mid-day, and a few drops of rain fell. At this time I discovered eight *Sceliphron* on the elderberry bushes, intently walking up and down the stems. In a few minutes the sun shone brightly again and they flew away. I watched the bushes for their return, but they did not appear. Soon after that another cloud darkened the sky, and four wasps promptly reappeared. They walked about nervously on the stems, and when the rain fell fast they all flew away, probably to better shelter. They may have been only seeking prey; if they were really seeking shelter, they certainly would have found better at their nesting-sites.

On several evenings some of these wasps accompanied *Sphex (Ammophila) pictipennis* to their regular sleeping places on the elderberry bushes, but each time they soon wandered elsewhere. (see p. 231).

Sphex (Ammophila) **pictipennis** Walsh [S. A. Rohwer].*

In my garden are three elderberry bushes fifteen feet apart. At this particular stage of growth they all bore unripe berries. I mention these facts in detail because while the plant was comparatively abundant in the vicinity it was on one bush, the middle one, and on only one cluster of green berries that certain sleeping performances of *Sphex pictipennis* were staged.

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*Following the suggestion of Dr. Cockerell in the Ent. News, we place in brackets the name of the gentleman who kindly identified the species for us.

At twilight, July 14, 1913, three insects were resting on this umbel of berries. They were just beneath the spray; their position was horizontal, their mandibles locked around the petiole of the berry, and most of their legs were hanging free in the air. In this they practically agree with the observations by Mr. Banks. He notes them in a horizontal position on the tall grass, holding on by the mandibles, but with the legs touching the stems.

At first, the insects were disturbed by my presence, but later in the evening they showed no signs of consciousness of me when I pressed close enough to ascertain that the mandibles merely formed a circle around the stem, and did not bite or pierce it or draw out its juices. All three were females. They had to be taken up with the forceps in order to ascertain the sex; one was kept for the cabinet and the other two were replaced but they were too sleepy to hold on and both fell to the ground, and could only summon enough energy to creep half way up again. At 7 o'clock the next morning they were in the same places, but highly alert; when I approached within five feet of them they were up and away, while only a little while before they had been too sleepy for self-protection. After the rough handling they had undergone in the examination I hardly expected them to return, but to my surprise at 6 that evening I found on the identical cluster not alone these two but three additional ones also. From 6 until 7:30 they were nervously walking about on the cluster and twig. The antennæ were actively in motion. Several times they flew to a near-by bush, but always returned soon to their original cluster. At one time they were followed by two *Pelopoeus caementarium*, but these soon left. At 7:30, however, they all seemed to be quietly at rest in their characteristic positions on this chosen spot.

Had these two wasps then really communicated with the other three and induced them to sleep on the same bush? Or had these three followed the original two? Or had these five arrived at the same spot by mere coincidence? Let me say that I could perceive no sociability among these five wasps; while it was still light each nervously examined the vicinity independently, and finally sought a resting place on this one cluster, from one to three inches apart. Therein they differed from *Chalybion*.

I then decided to mark them to see whether the insects coming each evening were really the same ones. It was very near dark, and an inartistic piece of work it was, but they must have been in deepest sleep, for they were motionless while I applied the paint. At midnight not one of them had moved an iota, and they were so lost in slumber that when the candle was brought very near to them it aroused not the slightest response. The next morning found them in the same position; one by one they awoke, rubbed their antennæ as a sleepy child rubs his eyes, and independently flew away without ado, the last one leaving at 7:30.

At 4:30 that afternoon, (July 16), a vigilent watch was begun to see if the marked individuals would return, and if so whether they would come in a body or singly as they had gone forth. At 5:30 one wasp arrived and a half-hour later two more. Two were marked insects, and the third was a stranger. All hovered about from twig to twig and sometimes flitted off to other bushes for a brief sojourn, but the two marked individuals returned frequently to their favorite spray. At dusk the two were settled and ready for sleep in the accustomed place, but the stranger, probably finding the situation not to his liking, sought other quarters and was seen no more. The next morning the two sleepers were just as I had left them. That night the incidents were repeated in every detail, the two marked wasps (they were females) finally remaining and the stranger departing. On the succeeding night, however, only one of the marked wasps appeared to spend the night in the accustomed spot. Again a stranger, perhaps the one already mentioned, accompanied her and in the usual fastidious manner examined the twigs and found the place unsatisfactory and hied itself to another berth.

The next evening, July 19, the two marked wasps and the guest again returned and all of them again buzzed about their particular green cluster, and as usual the stranger departed. But the two old residents this time sought a place on two distinct bushes. A new situation had arisen this evening, however; a lot of disgusting, newly-hatched Hemiptera (*Anasa tristis*) were actively occupying the favorite spray. Hence we cannot be surprised that the two wasps, finding their abode usurped and their peace disturbed, departed after a short visit to other bushes. The one which had spent the night elsewhere gave no evidence to account for its wanderings.

I watched for these old residents every day, but it was not until a week later (the Hemiptera were by that time gone) that one returned to the old home to spend the night, but if it had been marked the paint had worn off. I did not want to frighten it away by marking it. The next evening, July 28, I found three wasps here, all unmarked, but they were more skeptical than ever (as would be expected of first-nighters). Every time I approached them they flew away, but persistently returned. I tried to find marks on them but could not; they may have been my lost friends with their identification marks rubbed away. I could not bring myself to annoy them with markings, so I left them, hoping they would return with their friends the following night, but they returned no more.

Later in the season, October 7, I saw three wasps of this species asleep out in the field. Here too they were in their characteristic position, the body stretched out horizontally, the mandibles encircling a twig and most of the legs hanging free in the air while the others lightly rested, in a casual way, upon the twigs beneath. Two were on sweet clover and one on goldenrod. Others of both sexes were seen during the last half of August, in the regular position upon erigeron or white snakeroot. One was found hanging vertically by the mandibles. Their way of spreading out their legs in the air may be a form of relaxation.

Elis 5-cincta Fabr. [S. A. Rohwer].

These wasps are probably parasitic upon certain beetle larvæ; they build no nest, but sting their prey in its natural habitat, deposit an egg thereon and leave it.

On a hot day in July, 1912, we found at 4 p. m., hundreds of *Elis 5-cincta* at rest on the partly submerged vegetation of a temporary pond. When we neared them they all flew away but eventually returned. The remarkable aspect of the affair was that all of them were males. We supposed that the excessive heat of the day had driven the males to rest early, and that the females would soon follow. No similar congregations were to be found on the surrounding vegetation, although this field abounded in both sexes of this species, and especially the females were plentiful and at work on the white flowers of the melolotus at the time that these males were at rest.

In August of the following year at Lake View, Kansas, sufficient observations were made on the sleeping habits of these insects to prove that in this instance the males had not congregated for the purpose of meeting the females, but that the males alone of this species are gregarious in habit, and perhaps all in the region 'round about occupy one centrally located sleeping place.

One such colony we discovered asleep on a clump of *Aster multiflora*. The plants were two feet high, and with their low, spreading branches covered an area of two by three feet. They were three feet from a small creek and about ten feet from a high mud bank on the other side. Although for a good many evenings we examined all the vegetation in this vicinity we found no sleeping *Elis* elsewhere. Only the males occupied this bush, and only at night; they did not use it as quarters for midday rest.

While it was still a little light these too were shy and were easily frightened away, but before night they crept back one by one to their own roost. Several times each night for several nights I gently stirred the bush to see them scamper off, but always when I returned after an absence of fifteen or twenty minutes the bachelor quarters were again filled. These oft-repeated disturbances did not discourage them. For a period of five nights and mornings I examined this bush and saw only males, but still I thought that closer examination surely *must* show a few females present. So early one morning, when just a faint streak of daylight was appearing, I found all on the bush fast asleep, and with rapid sweeps of the net I took about one-third of them, 105 individuals; there was not a female among them. Even while I was picking the insects out of the net some of those which had escaped returned to the bush; even the commotion of sweeping the bush had not permanently frightened away those which had escaped me, and the bush was again teeming with inhabitants.

The following details for 1914, both at St. Louis and in Kansas, show that the sleeping conduct already recorded is not due to local or environmental conditions, but that their behavior is constant despite the intervention of time and space.

On July 18, at Lake View, Kansas, another large colony was discovered still asleep at 5:30 a. m. I shook the plant vigorously to note their behavior; they did not fly high in the air as they do early in the evening, but dropped to the grass below, spreading their wings to ease their descent. Here we have at once conclusive evidence that this massing together of great numbers does not afford protection from the birds, because they all behaved thus stupidly, making no effort to escape when attacked at an hour in the morning when the whole bird population is alert and riotous with activity. I cannot say whether the weather, light or some other factor caused their behavior to differ this time from the previous morning experiment.

About the middle of August a colony was found in a clump of *Erigeron canadensis.* Night after night they returned to these same four or five stalks, several hundred strong, and all males. The whole made a pretty group; the tall, stately plants were in themselves graceful; the stem for about one-third of its length was literally covered with the delicate, bright-colored bodies, while each slender leaf bore one, or occasionally two, on its lower surface.

On August 13, it was cloudy and dark at 6:30 a. m. About two hundred males of *Elis 5-cincta* were still asleep on five plants of *Erigeron canadensis* within a radius of three feet. They were ranged without crowding in single file on the long, narrow leaves and stately stems. When disturbed they dropped languidly to the lower leaves or the ground.

The next morning the gloom continued. At 10:15 a. m., the *Elis* still remained on their customary sleeping-quarters, too indolent to bestir themselves on a dull day. By 4:30, a high wind was blowing; they were rocked violently to and fro on their tall stems without being stirred to flight, but the approach of my forceps at once caused turmoil among them. By 6:30 the sun shone brightly, but *Elis* remained at home.

On the same dull day three other colonies were found on the under side of the broad leaves of some weed, but I cannot say whether this was their regular sleeping quarters or whether they had thus come together for only temporary shelter from the threatened storm. One group comprised 25 individuals, another 15 and the other 12.

A thick mass of weeds, especially Erigeron, bordering a large, open space of ground, seems to be a favorite habitat of *Elis.* In the middle of one such spot about two hundred yards in length, we found a crowded clump of 27 plants each bearing from 2 to 60 males. Although it was past seven o'clock on an August morning and the sun was high, all were still at rest.

At 5:30 in the afternoon, while it was yet full day, I examined two large dormitories of *Elis* and found almost all of them in their sleeping position already, although they were yet very susceptible to even a slight movement at some distance. One of these groups occupied certain plants in the heart of a clump of Erigeron. By 7:05 o'clock when I returned to the place they were at rest on these plants in great numbers. Suddenly, without apparent provocation, they all arose and flew about in circles for several minutes before they again settled. Some cause other than myself was responsible for the disturbance, for I stood fifteen feet away. The behavior was the more strange because they had become well settled in the hour and a half since first I had found them there. Furthermore they settled promptly to perfect quietude again, so that only a few minutes later I removed a whole plant with one vigorous stroke of the knife and carried it some distance without perceptibly disturbing them.

One month later, September 24, one lone male *Elis* was found sleeping at 6 p. m. in the head of a white snakeroot. This one, the belated straggler of the season, was the only one I ever saw sleeping in solitude. It was the last seen that year; neither have I been able to find them earlier in the season than June 16.

Thus it is clear that this gregarious sleeping institution is not a thing merely of local origin but one deeply ingrained in the species. Yet in spite of these observations on so many hundreds of the wasps, we have no light upon the question of why the males congregate thus and where and how the females sleep.

Prionomyx atratum Lept. [S. A. Rohwer].

One side of the road was lined with clumps of *Erigeron canadensis.* These tall, slender plants were at this stage of their growth about five feet tall. They seemed to be the dormitory of the wasps of this species which worked in a near-by corn-field.

At 5:30 o'clock on the morning of August 13, I found six wasps sleeping very close together at a point about three inches from the apex of one plant. The other stalks harbored no insects at all although they grew very close together in this one clump. I mention this to show that they could as easily have chosen plants of the same species and equal desirability very near for independent sleeping quarters if they had been so inclined.

In another clump of the same plant a short distance away, three wasps were asleep in the same huddled condition, and on the identical part of one plant, clinging to the stems with the legs instead of the mandibles, as do some other species of wasps. On another scattered group of *Erigeron* not far away, four of these insects were asleep on the tops of four distinct stalks.

At the same hour of the morning three days later I examined a patch of Erigeron in another location and found that the wasps rested in the same manner very near to the top of the plants. Five of these plants harbored one each, and five others bore from two to eight. In every case they were crowded together near the top. The sex was ascertained for 24 of the last lot; they were exactly equal, 12 males and 12 females. Early in the evening they were alert and easily alarmed, but by ten o'clock they could be approached with a strong light, or the stalk upon which they rested could be stirred without arousing any response in the wasps. Even the strong light and warmth from the carbide lamp held for several minutes within five inches of them did not arouse them or delude them with the idea that daylight had come.

Records of about fifty other individuals of this species, at different times and places, show conduct as varied as this; about half of them slept alone, near the head of ironweed, white snakeroot and similar weeds, while the others spent the night in groups of from two to eight, or in one case as many as sixteen. Thus the gregarious tendency is sometimes, although not always, present. In only one instance am I positive that a certain individual came back a second night to sleep on its own particular twig, but the habit of returning night after night each to its chosen spot may be common among them. It would be of interest to ascertain whether this is a fixed habit among them, or only a trait appearing occasionally, a habit developing or declining.

I could ascertain no conditions deciding the question of whether they would sleep singly or in the company of others. Both sexes were present, but I have never observed mating in these night assemblies; the only instance of mating that I have witnessed in this species occurred during the day. I do not see how safety would be increased by either their aggregation or isolation; if the insects' color and weapon prove sufficient protection for it through its solitary life by day while its enemies are alert, I do not see why it should need further provision for protection at night. Hence the question of the cause or purpose of this imperfect gregariousness still remains open, and even more important than this is the problem again of whether this tendency is ascendant or declining. We may have here the opportunity for a study of the rise of instincts; if so, it will be worth long observation and careful treatment.

Priononyx thomæ Fabr. [S. A. Rohwer].

June 8, 1915, this wasp was asleep on the top of a weed about four feet high on a northern slope of a hill. After being handled rather roughly it eventually roused itself enough to walk when prodded, feebly dragging one foot after the other, but it could not summon enough energy to resume normal activity.

Another was found July 22, at 7:15 p. m. on the top of a dried plant on a hilltop, and a third was clinging to a sweet-clover stalk on a gloomy September evening.

Chlorion (Protosphex) **ichneumonidæ** [S. A. Rohwer].

One July evening at 7:35 when it was almost dark I came upon a sand-wasp at rest, apparently ready to retire for the night. It sometimes turned its body languidly about and occasionally cleaned its face and antennæ, and once it cleaned its wings by thrusting its abdomen above them and rubbing them down.

Two months later, on a gloomy September morning at 8 o'clock, a female sand-wasp was found still asleep on a stinkweed, rather inconspicuous among the fine-cut foliage.

Bembex nubilipennis Cress. [S. A. Rohwer].

These wasps who work so intensely at digging their holes in the earth during the day find shelter in the same hole at night, at least the females do; we have never been able to locate the males' whereabouts at night. It seems the wasp uses her hole in whatever condition it may be, finished or unfinished. At the approach of twilight she creeps into her burrow and from inside she throws up a loose mound of earth to cover the opening. In the morning, when the sun is high enough to begin to warm the earth, she may be seen scrambling and wriggling out through this loose dirt; if perchance a shower has packed it during the night she emerges looking not a little dishevelled and excited from her exercise butting down her door.

We have opened the nests at twilight and found the mother sometimes in a hole only begun, sometimes almost finished, and at other times already occupied by the larva and its food.

One hole has continued to arouse our curiosity. We had watched it for over a week, waiting for its permanent sealing. Finally at twilight one evening, in company with Mr. E. A. Schwarz, we broke open its temporary closure, and to our amazement found six Bembex in the hole to spend the night. In my astonishment I let four escape, but the other two were females. I can hardly think this nest was for sleeping quarters exclusively, for we have never found another like it, and only the day before I had seen a female enter and depart several times as if it were a normal domicile. Is it possible that this may be an example of the beginning of the gregarious or social habit of wasps?

Philanthus sp. [S. A. Rohwer].

In a Kansas wheatfield on August 14, at 6:30 in the evening, a *Philanthus* was found very artfully concealed among the long beards of a head of wheat which had been missed by the harvester and had by this time turned dark grayish-brown.

Astata pygidialis Fox [S. A. Rohwer].

At the end of a dreary August day we found an open hole in our wasp-field which had not been there that morning. There was a little mound of earth outside, but no pretense of closing the hole. It ran down diagonally for about an inch and a half, and snug inside was the owner, *A. pygidialis*. It remains a mystery where this little proprietress spends her nights when her burrow is finished and sealed, or when she has no hole at all.

Rynchium dorsale Fabr. [S. A. Rohwer].

On a July evening just before twilight I found the hole of a *R. dorsale*, with its occupant therein ready for the night. I removed it with the forceps but when I tried to tuck it back in its nest it flew away.

It was deep twilight a few evenings later when we opened the hole of another and found the owner snug in its burrow, resting as calmly as though it were not expecting intruders at such an hour.

Odyneris firmus Cress. [S. A. Rohwer.]
Odyneris geminus Cress. [S. A. Rohwer]
Odyneris sp. [S. A. Rohwer].

The individuals of these species show marked variations in their habits of sleep, sufficient to lead one to suspect that they curl up and sleep wherever it is convenient at the moment of twilight. We have found *O. firmus* sleeping in its burrow and on vegetation; one was curled around a leaf of Erigeron, and another was in the seed-cluster of a pigweed, in such deep sleep that it unresistingly allowed itself to be picked up repeatedly. *O. geminus* was found in September, clinging to the Melolotus stalks, and a turret-building Eumenid was sleeping in her finished burrow, beside her egg and its first caterpillar.

Vespula germanica Fabr. [S. A. Rohwer].

At 6:10 a. m., on August 18, this Vespa was just beginning to wake up and stretch itself under a green curled leaf of Hibiscus.

Polistes.

When one comes upon a paper nest of Polistes at night he finds the inhabitants quietly at rest, their bodies and legs spread flat against the surface of the nest. I believe they are fully asleep; one may hold a strong light near them for several minutes before they show the slightest response.

Despite the fact that the nests are filled with sleeping wasps, one occasionally finds solitary stragglers asleep among the vegetation. They are often seen foraging or getting nectar when it is almost dark, and it is probable that these are overtaken by night while away from home. During the summer probably twenty individuals in all were seen asleep on the flowers of snakeroot, ragweed and sweet clover. The species were *P. pallipes*, *rubrigenosus*, *aurifer*, *annularis*, *variatus* and probably *bellicosus*. They are up and busy early in the morning; a *P. aurifer* came to a pond for water at 6:15 one August morning, and a *P. pallipes* was flying from plant to plant at 6:30.

HORN-TAILS.

Tremex columbia Linn. [S. A. Rohwer].

On a number of evenings from July to October, I noticed these horn-tails nervously flying about my mulberry bushes, and finally as twilight fell, selecting a roosting place on the under side of a leaf, and always among the lower branches. Whenever I noticed them during the night or early the next morning, I always found them in the same position.

On the evening of October 2, one, after buzzing about for a few seconds, alighted on the under side of a low leaf of a sycamore tree, and there she remained, sleeping until dawn. An examination by candle-light at 10:30 found her unchanged.

While this horn-tail was buzzing about seeking a leaf among the lower boughs under which to sleep, the upper branches of the old sycamore were filled with uproarous sparrows but she feared them not and sought her place and went to sleep, while a little later the sparrows did the same. This circumstance at once suggested an explanation of the usual peculiar choice of this insect. The under side of the leaf, which was invariably chosen, would afford protection from the view of birds, but this only among the lower twigs, which likewise were always selected. It is obvious that a species which followed an instinct or habit of sleeping on the upper side of leaves, or even on the under side of leaves among the topmost boughs, would rapidly be eliminated by the bird population.

BEES.

Melissodes obliqua Say. [J. C. Crawford].

In an open field which sloped toward the River des Peres, St. Louis, was a burnt area about ten feet square. The grass was burned off, but the charred stalks of weeds two or three feet tall were still standing.

When walking along a path through this plot at 6:15 in the evening of July 19, we disturbed a number of bees. They buzzed about the plants, waiting for us to go on, excepting perhaps a half dozen which remained undisturbed. Two of these were huddled together on one dead leaf, so frail and dry that we wondered that it did not break down with their weight.

An examination of the surrounding vegetation revealed no others, although the swarm was buzzing impatiently about awaiting a quiet chance to alight. So we left the spot and returned an hour later. Now we found the 28 bees clustered near the tops of a small clump of stalks. Since it was now almost dark, my presence did not disturb them. They were huddled together in groups of 2 to 5, with only 3 insects occupying their sites singly. They were settled for the night in their characteristic posture, resting on their support with the head downward, the abdomen ventrally curved as far as their chubby forms would permit.

It is hard to refrain from calling this a case of protective environment rationally chosen by the insect. I surely would not have seen their brown bodies blending with the dingy burned leaves, had I not known just where to look for them. In another field about a quarter of a mile distant the sweet clover was abundant, but a careful search revealed no bees.

The next evening 29 bees, only one more, were asleep on these five stems, all clustered on the apical three inches of the dead plants. On the top of another plant ten feet away, 2 were at rest. All were in the same characteristic position. If they had chosen this site for protection alone they would have rested singly on the plants, but since they huddled in groups, they must have sought sociability also. They were so close together in some cases as to arouse my suspicion about their mating, but a close examination proved the idea false.

The following night, July 21, 24 of these bees were here to spend the night in the same way. On the 22nd, 30 were present. On this evening I marked part of them with white paint in order to make sure whether this uniform group was made up of the same individuals night after night. As fate would have it, by the next evening a cow had broken down their chosen stems, so none of the bees were there. However, 15 were found on similar weeds near by; 7 of these bore the white markings. This gave evidence sufficient to prove that the same bees return to their chosen spot regularly. Part of these were taken to see whether one or both sexes were thus gregarious; of the 18 taken, all were males. They made no attempt to move when picked up with the forceps, while earlier in the evening they could not be approached without a heavy buzzing and flying about.

For some reason the group dwindled from this time on, and each night a smaller number came back; perhaps the disturbance of the cow's intrusion drove part of them away. Up to the end of July from 2 to 4 were usually found asleep at night; these faithful ones were always on the same twigs near the original roost.

A second burned area was found some three hundred feet away, similar in all respects to the first and surrounded by green vegetation. Around the periphery of this burned patch no bees were found, but in the center, on a cluster of five brown stems, 14 bees were at rest. Most of them were huddled together in groups of 2 to 7. All were at rest on or near the tops of the plants, head downward, with the characteristic ventral curl of the abdomen. Here again the bees had chosen this dull spot which so delicately suited their coloration, and away from the edge of the patch. In the early twilight many of the bees were busy cleaning their necks, eyes and antennæ with their front feet. No others were found anywhere in the vicinity.

This group of bees, about 14 to 16 in number, also came repeatedly until the end of July, when the group dwindled and suddenly and mysteriously disappeared. By marking the insects we assured ourselves that the same individuals came back night after night.

In the centre of a thick clump of white snakeroot almost ready to bloom was a dried stalk of the same plant from last year. Crowded together upon the head of this one dead plant were 40 of these bees. All were head downward, in precisely the same position as described before, and were quiet excepting for movements of the legs when cleaning themselves or kicking their neighbors. They were thus settled for the night although the sun was still well up at 6 o'clock on an early August evening. Here is another case of bees selecting dried plants of their own color.

Alongside the green plants bearing *Priononyx atratum* mentioned before was a dried stem; this too was the chosen resting place of 4 of these bees, although green plants were much more abundant all about.

On August 4, 19 bees were still at rest on some bushes at 8 a. m., when the whistle of a passing train caused some of them to fly away. It must have been about their normal hour of rising, for within the next three minutes all the others departed singly for their days work.

A considerable number of other observations in St. Louis and eastern Kansas find these insects usually coming together in groups of 2 to 50 to sleep, although occasionally solitary individuals are found. In almost every case a dead dark colored weed was sought out and given the preference over the surrounding green vegetation. None have been seen in the vicinity of St. Louis later than about the middle of August, although they have been sought.

In one case a single bee was found repeatedly snuggling in the heart of a large group of *Priononyx atratum*. It came here regularly with the wasps before 5:30 p. m.

When the bees were at rest one could see some of them completely covered with yellow pollen. Since about twenty were taken in this condition from sunflowers I take this to be sunflower pollen. Others were dusted with whitish powder, probably snakeroot pollen. One evening I was intensely interested in watching one insect caressing the abdomen of a neighbor with her own. I expected to witness an actual courtship and copulation, but it soon proved that she was only cleaning the pollen off her own body on to her neighbor. They frequently cleaned themselves before going to sleep.

The problem of the purpose or cause of some of the insects coming together thus to sleep remains an open question. So far as we can see they could sleep as well on the individual flowers upon which they feed or near their places of nidification. Their persistent choice of the dull, dead plants strongly suggests an element of protection in this selection. Besides the fact that this dull color is in harmony with their own, it may be that their enemies would be less likely to seek for prey upon old dead vegetation than among the green plants which usually harbor insects. But it does seem that the selection of these dark, dried twigs is a conscious choice.

Melissodes argilis Cress. [J. C. Crawford].

This species of long antennæ bee we observed both at St. Louis and Lake View, Kansas. They hied them to the sunflowers at twilight and almost always squatted flat in the disk, usually one in each flower. They did not hold on with the mandibles, but I think they slightly buried their tarsi in the florets. They seemed to be heavy sleepers and seldom awoke when handled or when the light was flashed upon them.

In one instance, on September 2, the stem and flower containing a sleeping bee were rudely jerked off, carried about a quarter of a mile rather roughly and placed in a cage. The next morning the bee was still asleep in exactly the same position, evidently having not moved during the night.

In all, ten bees were observed in the two remote localities. In every case they chose the sunflower and they always spread themselves flat so that their abdomens touched the florets. By thus sleeping beside their work they were ready to resume their tasks bright and early the next morning. I have seen them at 5:45 on an August morning flying from flower to flower already laden with yellow pollen.

Melissodes obscura Say. [J. C. Crawford].
Melissodes bimaculata Lep. [J. C. Crawford].
Melissodes verroniana Robt. [J. C. Crawford.]

On some dead dock plants standing amid green vegetation on a hill-top were three little bees huddled close together around the stem. All three were of different species, one *M. obscura*, one *M. verroniana*, and the third escaped without identification. On a similar plant, similarly situated a few feet distant, was another group of three curled around the stem in the same manner; two were *M. obscura* and the third was a distinct black bee, *M. bimaculata*. I should like much to know whether these little bees of this genus are always so select of their company and the nature of their sleeping place.

Apis mellifica Linn. [J. C. Crawford].

On June 9 the sun was getting high by 6 o'clock in the morning. I was walking along Watson Road, St. Louis, when I noticed two worker honey-bees still asleep on a cluster of elderberry flowers. One was picked up with the forceps; it was sufficiently awake to move the legs. The second one moved not at all, even when picked up. Closer inspection revealed a white flower spider, *Runcinia alœtoria* Htz. [N. Banks] clinging to the ventral surface of this bee, which was dead. Here this little protectively colored spider had succeeded in capturing the bee asleep. I think it could hardly have discerned the prey in the dark, but that it probably saw the bee and captured it with the first rays of dawn. Bees are supposed usually to spend the night in the hive, but in all probability these were foraging when darkness overtook them. They probably work both early and late, for on August 18 six honey-bees were seen in the newly opened flowers of the jimson-weed, while the same week many were to be seen flying from flower to flower covered with green pollen at the early morning hour of 5:45.

Emphor bombiformis Cress. [H. L. Viereck].

Seven individuals of this species came to the elderberry bush in my garden while it was still light; at 9 o'clock they were in such deep sleep that they could easily be marked. Owing to poor light however, the work was awkwardly done, and the next morning two were found disabled. The others never returned.

Triepeolus helicanthe Rob. [J. C. Crawford].
Triepeolus lunatus Say. (J. C. Crawford].
Triepeolus concolor. [J. C. Crawford].
Triepeolus concavus Cress. [J. C. Crawford].

We have discovered no hard and fast rules for the sleep of these little bees, excepting that, like most bees, they faithfully keep regular hours, from about 6:30 p. m. until the sun is well up in the morning, and that they habitually choose a leaf or twig of a weed about two feet above the ground as their resting place, although the vegetation was of various heights from two to six feet.

The specimens of *T. concolor* which we have seen were simply sleeping on stems in the position they assume during the day. Our three individuals of *T. concavus* followed each his own fancy in settling to rest; one was curled around a stem, another tightly clasped a leaf of Erigeron with its mandibles while its legs were free and the body horizontal, and the third assumed a comical position, just hanging over a little stem by its middle like a small boy hanging over a rail fence on his stomach.

The little *T. lunatus* were found still in deep sleep at 6:35 on an August morning. They were sitting in an easy, natural attitude, each on the top of an Erigeron leaf, and they were so helpless at this hour that when brushed off they fell down as if dead.

We have observed *T. helicanthe* upon only two occasions. They were grouped in small colonies of three and five. In every case they clung to a little stem by the mandibles while the feet rested lightly upon the vegetation and the body rested head downward.

Calliopsis nebraskensis Cwfd. [J. C. Crawford].

On August 7, when it was nearly dark, I opened a nest of this little bee. She was near the top and I suspect she was still at work for some of the loose soil on top of the mound at the mouth of the burrow seemed quite fresh.

Chrysis perpulchra Cress. [S. A. Rohwer].

These beautiful green cuckoo-bees are very conspicuous near the top of the Erigeron at about the height of a man's shoulder or eye, where they settle to rest in the late afternoon. As long as the daylight lasts, however, when they may still be seen, they are too alert to be in any danger of being captured; only when covered by darkness are they helpless. They usually wrap their tiny bodies horizontally about the small vertical stem or petiole of the leaves or flowers. They probably return to the same sleeping quarters night after night, for I found them on the same clump of plants on three successive nights.

FLIES

Proctacanthus milberti Macq. [F. Knab].

Robber flies have a most tantalizing way of evading capture; as one draws near them they remain alluringly motionless until one brings down the stroke intended for their capture; at that instant they fly away with a loud buzz only a short distance and alight again to tempt one and repeat the performance. In the evening they behave in much the same way when approached until twilight is far advanced, when they relax into deep sleep at about 8 o'clock, resting on the vegetation at a height of about three feet from the ground, and may be picked up with perfect ease. Their night position is not different from that of the day, but the feet automatically grip the support firmly. Whenever taken, whether awake or asleep, they always exude from the anus a drop of brown, pasty substance; I do not know whether this is the normal function of excretion or some special means of protection to ward off the attacks of enemies.

A pair of these robber-flies in copula were watched at Lake View, Kansas, August 18, at 7 o'clock in the evening. These two followed the same tactics of resting and flying for short distances when pursued.

Sparnopolius brevirostris Macq. [F. Knab].

Near a dozen yellow velvety bee-flies were seen at twilight early in September, gracefully resting on various flowers and leaves, but not one could be caught, even by extreme effort, so quick and agile were they.

While I feel confident that they spend the night in the position in which one finds them at dusk and they eventually relax in sleep thus, yet they are more active and alert throughout the twilight period than any other insect I have met among the higher, swiftly-moving insects. Only late in the season, when the weather grew chill, could they be taken at the twilight hours when most other insects could easily be picked up. They do not congregate in definite swarms to sleep, but frequently a half dozen or so are seen occupying neighboring ragweed or other plants.

Argyromoeba obsoletum Loew. [F. Knab].

On July 29, two of these bee-flies were seen asleep, one on the under side of an overhanging rock by the Meramec River, and the other on a twig sheltered by a protruding rock by the roadside. It was quite dark and both must surely have been asleep, for neither my bright light nor my hand when I picked them up disturbed them, although they are normally very active Diptera.

DRAGON-FLIES.

Libellula pulchella Drury. [R. P. Currie].
Libellula luctuosa Burm. [R. P. Currie].
Anax junius Drury. [R. P. Currie].

Dragon-flies are swift and agile in their flight and are difficult to apprehend during the day, at least those species which are abundant in this vicinity. The sharp contrast between this and their behavior after dusk leaves little doubt that they lapse into deep sleep at night. I have noticed only a few individuals at night, but all of these had chosen for their roost a gray, dead twig among green shrubbery, about five feet from the ground. They rest with the head up, holding on with their feet and automatically clinging tenaceously. After they are soundly asleep, at 7 or 8 o'clock, they are indifferent to a strong light or even to being pulled off their support and handled.

ORTHOPTERA.

Dissosteira carolina Linn. [A. N. Caudell].

These grasshoppers are very numerous in the open fields or in the short grass at twilight, but one may beat the bushes and weeds in vain for them. They are protectively colored for their life on the ground by day, and they continue to make use of the same protection for sleep at night, resting on the gray earth or grass of open spaces.

Hippiscus rugosus Scud. [A. N. Caudell].

This fancy hopper is usually a long jumper, but at 6:30 on a September evening this one made two short flights when I attempted to take him, and refusing to move further he was bottled.

Arphia corinata Scud. [A. N. Caudell].

This grasshopper seemed to sleep more soundly than most of its brothers. One which was found on July 29, on the under side of an overhanging rock was not awakened by either my strong light nor my fingers' grasp.

Melanoplus femur-rubrum DeG. [A. N. Caudell].
Melanoplus atlantis Riley. [A. N. Caudell].
Melanoplus differentialis Thom. [A. N. Caudell].

These hoppers, like the others, seem to sleep at night right where they live by day. They are usually found at night or in the early morning clinging, head up, to the stems of stalky plants, such as Erigeron, horse-weed, corn, etc. Sometimes they are alert enough to escape when touched, but they are usually languid, especially in the morning.

Dichromorphia viridis Scud. [A. N. Caudell].

Only two observations were made upon this short-horned grasshopper, at 9:20 p. m. on June 10, at St. Louis. One insect was to all appearances asleep on a grape leaf and the other was actually feeding upon a leaf of poison-ivy, *Rhus toxycodendron*.

Stagmomantis carolina Linn.

Just how or when the devil's horses get their sleep I have never been able to discover, although I have kept many of them under close observation. The males are frequently to be seen at the lights, and the females in cages are able to capture prey in the dark. They also construct their egg cases after dark, and some of them remain in copulo during the night. These activities were observed during the daytime also. It may be possible that they snatch a little nap between activities whenever opportunity offers.

Amblycorypha oblongifolia DeG. [A. N. Caudell].

Perhaps a dozen of these green katy-did nymphs were seen at rest on the poison ivy, which at that time, mid-June, was tender and bore green berries. Five of these were actually eating the *Rhus*. Three others were at rest on pokeberry plants near by.

Orchelimum nigripes Scud. [A. N. Caudell].

This brown and green hopper was found at rest on the vegetation by 8:30 on different evenings in mid-August, but they were probably awake or sleeping only lightly for occasionally they would move slightly, and one which was picked up bit me so severely that I flung it away in astonishment and it escaped.

BUTTERFLIES.

Pieris protodice [H. Schwarz].

A stretch of vacant land in St. Louis about the size of two city blocks bore a good many patches of the white snakeroot, *Eupatorium ageroides* Linn. At the time when these observations were made the plants had gone to seed, and instead of the pure white flowers at the apex of each stalk was a fluffy mass of awned seed ready to be puffed away by the wind. These gray-white, feathery tufts seemed to be the favorite resting place of *P. protodice* for the period from October 6 to 18.

When walking through the field at deep twilight I saw a number of white spots on top of the grayish heads of this plant, very conspicuous indeed. In this one patch of about twenty-five square yards I counted thirteen of these butterflies, but on the other plants near by, such as sweet clover and yellow daisy, none were sleeping.

It was noticeable that they all thus chose the same kind of plant, but more remarkable was the fact that every one of these butterflies rested horizontally on top of the seed mass with the head toward the south. A soft wind was blowing from that direction, and a south wind in October may have been sufficient stimulus to excite this choice of position.

An inspection of the field on several other days yielded the following data:

October 7, at 5:30 p. m., 26 individuals of *P. protodice* were asleep on three species of plants as follows:

On the seed-mass of white snake-root	17
On the white flowers of *Aster multiflora*	7
On the white flowers of *Melolotus alba*	2

The goldenrod in bloom in abundance near by bore none at all. They all were fast asleep so they could be picked up and replaced on the twig or even on my coat. Two of them clung thus to my coat all the way to my home, a distance of two blocks. These 26 insects rested horizontally on the top of the flower with their heads in the following direction:

South, 15; East, 4; North, 3; West, 4.

The direction of the wind could not be ascertained on this evening; there was very little and it seemed to be variable.

On October 14 at 5:40 p. m. the wind was directly from the south. The butterflies were again at their old haunts and asleep. Of the 34 examined this evening, 28 were resting horizontally on the tops of the white snakeroot, and 3 just below, in a vertical position head upward, and 3 were on the goldenrod in a vertical position. And, it surely cannot be mere coincidence again, every one of the 34 directly faced the south.

In addition there were this evening three yellow butterflies, *Colias eurytheme* and *C. philodice*, on the goldenrod and snakeroot. Two were in the same position in relation to the wind as above, and the one on the goldenrod was in a vertical position with the ventral aspect of the body toward the wind.

The next observations were at the same hour on October 17. The temperature had fallen by this time, and a chill wind was blowing from the southwest. There were only 14 butterflies to be seen, 12 of them resting on the tufts of the snakeroot, and 2 on melolotus, but each and every one of these insects was facing the south.

By October 18 a more pronounced drop in temperature had occurred. A careful search revealed only one butterfly. The wind was from the southeast, and this numbed insect was facing north. The next day was cold and none were to be found in the field.

The above notes on the position of sleeping *P. protodice* were for only October. We thought that the insects' behavior may have been influenced by the autumn weather, and it seemed desirable to know their sleeping behavior during the entire summer. The notes below give this data for the following year.

A hillside gently sloping toward the north was covered in the early summer with horseweed, wild tansy, ironweed, poison ivy, dock, etc. In the center of this variety of vegetation was a patch, about fifteen feet across, of the white milkweed in flower. On these plants at about 5:30 p. m. were hundreds of these white butterflies feeding, flying about, and a few pairs mating. "What an opportunity," thought I, "to return at twilight and see how the insects orient themselves in reference to wind, light, etc., when preparing to sleep, with sufficient numbers in a limited area to make the data conclusive."

At 7:25 I returned to this spot, but where I looked for hundreds to be asleep on the plants upon which an hour before they had been so exuberantly drinking in all the goodness of life, I found but two fluttering from flower to flower, sipping here and there, and soon these too disappeared. They had left off their gregarious habit of the day and each one had individually sought his own resting place for the night. A few of them were found on near-by bushes, iron-weed, horse-weed and low grass, but these were only a small part of the splendid flock; most of them had flown to some distant place. The nearest butterfly was ten feet from the food-plant, and not one rested on the milkweed.

Since so few were in the immediate vicinity, they never occurred more than one on each plant, and they all rested in a vertical position, with head up. In the question of their relation to the wind we have two points of environment to consider: some of the butterflies rested on low plants and grass in places protected from the wind, and others rested on or near the tops of tall plants, in places exposed to the wind. A gentle breeze was blowing from the east at this time; when we examined the butterflies at rest on the high plants in the full sweep of the wind we found them with the ventral side of the body facing:

East, 22; North, 1; West, 0; South, 1.
Northeast, 3; Southeast, 1; Northwest, 2; Southwest, 0.

This shows that not one was holding its position with its wings against the wind, but that 26 out of 30 were facing entirely or partly toward the east, so the wind could not force their wings open.

Of those in the sheltered places in the low grass we have a smaller number, and in the following positions:

East, 1; North, 5; West, 1; South, 0.
Northeast, 0; Southeast, 1; Northwest, 0; Southwest, 0.

Here in the sheltered spots we find 5 out of 8 facing northward. We could find no reason for this condition unless the moving air was deflected from its course there among the lower vegetation.

If the sleeping butterflies were disturbed early in the evening they would fly to another plant; if disturbed later, just about dark, they would drop helplessly to the ground or a lower leaf and remain there. We routed twelve sleeping butterflies in the early twilight to see in which direction they would fly in choosing their new location. Every one of them flew westward, with the wind. Three of them at first fluttered faintly toward the east, but in a moment they righted themselves and floated westward.

Similar observations at twilight on June 16, when an east wind was blowing showed 39 out of 45 facing windward.

On August 26, about 90 sleeping *P. protodice* were counted, mostly upon the ragweed. The vegetation upon the field was stunted and low, and the wind had a clear, open sweep across it. The wind was from the east, and all but eight of these had their heads or bodies accordingly facing eastward.

On September 8 a strong wind was blowing from the southeast. Each and every one of the 55 butterflies in the field was facing toward the wind. Each one of these was picked up and thrown into the air; about half of them floated with the wind and the others went with much force against the wind, but in every case they soon whirled around and followed the wind.

Seven other countings of *Pieris* in different places and times showed the same orientation.

The question remains: do the insects intelligently orient themselves toward the direction of the wind, or does the wind, when they are languid, mechanically swing them around to the position of least resistance? We have not ascertained whether, if the wind should change its direction during the night, it would forcibly turn the butterflies about in their sleep or cause them to waken and shift their position. The helplessness of the drowsy butterflies when thrown up into the breeze, and the fact that about half of them tried but failed to go against the wind would lead us to conclude that this habitual position is the result merely of mechanical force upon the languid insects.

Minot points out that the allied species, *Colias philodice* and *Pieris rapae*, begin to alight on the grass and before twilight is ended they creep down to the roots of the grass-stalks and there spend the night in sleep. The difference in habits of those and our species may be due to meteorological conditions. Minot's observations were probably made at Boston, where the temperature and the breezes would probably be more trying in unprotected spots than at St. Loius.

Pieris rapæ Linn.

At 8:30 p. m. on August 17 this white butterfly was asleep on a pig-weed, sitting on the top of a leaf.

Nathalis iole, Boisduval [G. T. Hosenfelt].

At dusk during the early days of September hundreds of these little yellow butterflies may be found at rest or asleep on the grass or on the low twigs of weeds. If one walks through the vegetation while it is still light, they fly up in great numbers; if one attempts to take them he will have difficulty in doing so for they fly away without much provocation. But as darkness falls they become lethargic and may be picked up like blossoms.

They show to some extent the same anemotropism as do *P. protodice*; they always creep down to a sheltered twig near the ground, quite ignoring the many taller plants, as iron-weed and snakeroot, which abound near by.

Phyciodes tharos Drury [G. T. Hosenfelt].

We have a number of records of this species, noted during August and September, and each case differs from the others. Two were found asleep at 10 o'clock in a vertical position on the twigs of a dead willow five feet from the ground; another rested horizontally on the low branches of a cocklebur; another was found drowsily feeding at twilight on the disk florets of a sunflower, and still others were on the ground and on the tops of iron-weeds. They became drowsy and sluggish in the early evening, near 6 o'clock, but they do not fall into deep slumber until 9 or 10 o'clock, but even then they retain enough self-control and vigor to teasingly wriggle away from one when caught.

Pyrameis cordui Linn. [G. T. Hosenfelt].

This butterfly was found asleep just above my head on a cedar tree in Kansas, August 13. It was so languid that it was easily taken with the fingers.

Thecla melinus [G. T. Hosenfelt].

This red spotted butterfly was found asleep at 5:45 a. m., August 18, on the under side of a leaf of horse-weed, three feet from the ground.

Anosia plexippus Linn.

This milkweed butterfly is a rapid flyer during the day. That it actually sleeps at night I have no doubt after having observed a large number of them in eastern Kansas between August 8 and 18. They usually select the apex of some tall plant, like Erigeron, corn or horse-weed, or choose a twig of a tree at the same height, always about six feet from the ground. many are to be seen still on the wing at 6 o'clock in the evening, but by 6:30 they are settling down on their chosen roost for the night, and an hour later they are sleeping so soundly that they are powerless to escape when disturbed. They cling tenaceously to the support in their sleep, and are not aroused by a strong light falling full upon them. Even when handled they show no response, and when dropped, only flutter aimlessly and fall. They are commonly to be seen mating on the wing during the day, but sometimes spend the night in copulo and are very slow to separate when disturbed. They are early risers, and are actively flitting about long before most other insects. On three different mornings in August, many were to be seen flying about at 5:30 and 5:45 o'clock.

Argynnis cybele Fab. [G. T. Hosenfelt].

Lake View, Kansas, August 19. At 6:10 p. m. this silver-spotted butterfly was asleep on the under side of a red-haw leaf twelve feet from the ground. After vigorous and prolonged shaking of the bough it awoke and flew away; the next morning at 7 o'clock it or another of the same species was again fast asleep on the identical spot.

Atalopedes huron Edwards [G. T. Hosenfelt].

A good many of these butterflies were at rest on cedar and other trees at 8:30 p. m. and still the following morning at 6 a. m. At both times they would promptly fly away when touched, but they did not appear in the least disturbed by my carbide light. On two nights, August 19 and 20, they behaved in the same manner, so I do not know whether they were sleeping lightly or only resting.

MOTHS.

Hyphantria cunea Drury [G. T. Hosenfelt].

This species seems to sleep, or at least relax for a night's rest, in any spot convenient at the moment and without any regular manner or formality. We have found them resting after 7 or 8 o'clock upon a variety of vegetation—grass, sunflowers or weeds. However, they may not confine their rest to the night hours, for we came suddenly upon one which seemed to be asleep in the middle of an afternoon in September.

On September 24 I found seven of this species asleep on various plants in a field on a hill-side. It is interesting to note that every one of the seven rested directly facing the wind.

When picked up at night they often struggle clumsily to free themselves.

Hæmorrhagia tenuis Grote [G. T. Hosenfelt].

Only one specimen of this species has been taken while asleep. At Lake View, Kansas, on August 20, at 8:10 p. m. one was found sleeping on a cedar twig five feet from the ground. Neither the strong light nor my carrying it about on my finger disturbed it in the least or aroused its resistance.

Hæmatopsis grataria Fab. [G. T. Hosenfelt].

On the evening of August 19 many of these small yellow Lepidoptera were on the plants, some in copulo, but they were evidently only resting for they were agile in making their escape when we tried to take them.

Apantesis arge Dru. [G. T. Hosenfelt].

This species was noticed only in the latter part of August and early September. They seemed to go to rest for the night on the ground or on the first convenient stem at hand from six inches to three feet above the ground. Sometimes several occurred near to each other, but seldom more than one on a stem. At that time of year they usually rested, head up, on dead or dried stems.

Utetheisa bella Linn. [G. T. Hosenfelt].

This red mottled moth shows the same behavior night and day; when picked up it slowly opens its wings and so remains motionless.

BEETLES

Diabrotica 12-punctata.

Like the striped pumpkin beetle, these spotted cucumber beetles apparently behave at night very nearly the same as during the day. The two insects are often associated together; where you find one you have not far to seek for the other.

On June 10 at 9:30 p. m. several were at rest on the blossoms of the elderberry. I could not discern whether or not they were asleep. At the same hour on August 30 they certainly were wide awake, walking about on sunflowers and feeding on the petals. On August 15 at the same hour and at 6 o'clock the next morning they were in the flowers of the jimson-weed. When the cucumber blossoms were examined at 5:50 a. m. none were found in the newly opened blossoms, but in the old flowers of the day before which had already closed there were several of these spotted beetles. This shows that at least they are not active enough at that hour to migrate speedily.

On September 14 at 8:30 p. m. two spotted beetles were to all appearances asleep on the radial florets of a sunflower, but when the carbide light was thrown on them they gave a slight response in the form of movement of the antennæ.

From these observations I assume that this species has no regular hours or conditions to sleep.

Diabrotica vittata Fab.

I hardly think that these striped pumpkin beetles sleep during the night; at least many of them were active in the jimson blossom at 9:30 p. m. on August 15 at Lake View, Kansas. The next morning at 6 o'clock many of them were still in the blossoms, but I can offer no guarantee that they were the same individuals. Again at 5:50 a. m. on August 16 and 17 I found from two to seven individuals of this species in each of twenty pumpkin blossoms. Many of them were in copulo. Since these flowers do not open until early morning, this is evidence that they must have been awake and migrated during the night.

Copris carolina Linn.

Just after dark July 29, we followed the sound of a heavy, buzzing insect and turned our light upon a flying *Copris carolina*. It was hovering in the road above a pile of fresh horse-dung.

Canthon lævis [E. A. Schwarz].

This dung roller was often seen during the day buried under soft dung; sometimes it was abroad at night, up to 11:30 p. m., rolling and burying its ball. The periods of rest are very irregular, but since the animal goes into the burrow with its food ball and sits at table until all is eaten, perhaps sufficient periods of rest occur at these times.

Harpalus ruficornis [E. A. Schwarz].
Harpalus pennsylvanicus [E. A. Schwarz].
Harpalus caliginosus [E. A. Schwarz].

One can scarcely stroll out over a pasture field on a summer evening after dark without being greeted by these active beetles on the wing or ambling along the path or scrambling through the grass. But on a cold, damp September evening we have found *H. ruficornis* in their holes. Perhaps they all sleep in their holes at one time or another, just as it suits their convenience.

Limonius agonus Say. [E. A. Schwarz].

June 10, at 10 p. m. two of the small brown click beetles so common here at St. Louis were calmly at rest on a leaf of poison ivy. I could not discern whether they were asleep.

Lachnosterna.

Several of these may-beetles were found, when the light was flashed upon them, to be feeding on the leaves of the elderberry and grape on early June evenings between the hours of 9 and 10 o'clock, an hour when all honest insects are abed. We know they are abroad even later than this by the thousands which come to the lights.

Nemognatha lutea [E. A. Schwarz].

These yellow sunflower beetles inhabit the blossoms of sunflowers during the day, occasionally flying from one disk to another. They do not drop to the ground, as do some insects when disturbed, but they feign death for a short time by stretching out and stiffening the legs. They spend the night in the sunflowers in the same way, and if they really sleep one cannot discern it; the head and mouth-parts are usually covered with pollen, and the head is often buried in the flower, as are also the legs. When disturbed at night they feign death in precisely the same manner as during the day; from this I conclude that they are not really asleep, but perhaps only resting in the midst of their food supply.

Chauliognathus pennsylvanicus [E. A. Schwarz].

These beetles which are so common where flowers abound seem to sleep right in their day-time quarters, on the disks of sunflowers or daisies, or on the clusters of elderberry or white snakeroot flowers, etc. We have found them in great numbers, both singly and in copulo, resting on these flowers at night, from midsummer to autumn.

Epicauta pennsylvanica DeG. [E. A. Schwarz].

At dusk on August 7 about fifty small black blister beetles were clustered in the crannies of the inflorescences of a group of six goldenrods; none occupied positions on the plant below the flower-heads. They were apparently ready to spend the night, and many were readily taken. They did not drop to the ground upon slight disturbance as usual during the day, and one had to poke them persistently with a pencil to induce them to fall, but they did not cling so tenaceously to the plant as did their larger cousins. This may be due to the fact that the larger ones were visited later in the evening when they were more sleepy.

As late as September 11, on a cold damp morning a few of these beetles were still to be seen asleep on the goldenrod. Even later in the season, September 28, a few were still occupying the goldenrod, a number of them in copulo.

Macrobasis longicollis Lec. [E. A. Schwarz].

The larger blister beetle is a very agile, sensitive creature. They have the habit, developed to a remarkable degree, of dropping from their plant to the ground immediately upon the approach of the least provocation. In fact this dropping reaction is so pronounced in the blister beetles that when taking them we customarily place the cyanide bottle beneath them and merely touch them to cause them to tumble in.

On July 24 I found eight of these asleep on the iron weed. They showed no consciousness of the light, and did not respond to the disturbance by falling as usual. Here at night we found that they could be tapped repeatedly with a pencil and their only reaction was to walk a little distance and rest again—perhaps sleeping, we could not tell, sometimes on a stem and sometimes on the under side of a leaf. When the insect was forcibly thrown to the ground it would not feign death as usual but would immediately creep up the nearest stem and rest. This sometimes happened to be only a short blade of grass; in that case the insect would climb to the top of that but immediately come down when it found its altitude insufficient, try several others perhaps with the same result, until it would finally find a tall weed up which it would scramble in apparent glee, perfectly happy when it had reached the top. The insects sleep upon their food plants and have an aversion to spending the night on low plants or upon the earth.

A typical case of the behavior of an individual under experimentation is the following:

I awakened a beetle by hitting it hard with a pencil six times; it walked slowly to another leaf without the expected dropping. I pushed it from its support and forced it to fall to the earth; it immediately climbed to the top of its weed again.

Another beetle was at rest six inches from the apex of its food plant. I gave it twenty raps with the pencil when, instead of dropping, it crawled to the apex of the plant. When I left it in peace again it crept down to its own chosen spot on the plant. I then gave it six more hard licks, whereupon it sought shelter under a leaf near by. With sixteen more blows the insect walked to the under side of another leaf, and even with twenty more hard licks it could not be induced to perform the daylight drop. Becoming impatient, I carried the insect bodily to a nearby path. It walked about eighteen inches to a small plot of short grass, climbed to the top of one blade and tried to look out, and at once meekly came down and tried another. I took it up and carried it to an iron weed near by. Here it plodded its way faithfully to the top where it wearily settled itself. By this time my curiosity was fully aroused as to how much the beetle would endure without fully waking, but at this point the urchin who was holding the lantern exclaimed: "Aw! pick on somebody your own size!"

CONCLUDING REMARKS.

Scudder in 1889, in speaking of the butterflies at rest and asleep, says: "Up to the present time no proper investigation has been made in regard to the sleep of insects. A wide and open field lies before the enquirer, and it is for his use that I have tried to bring together a few facts concerning the postures and behavior of butterflies in different circumstances. The facts however are too few whereon to base any general statements likely to require no important modification on future investigations, and I leave them for the present barren of results in the hope of enticing some one to enter a promising field and perchance relieve these facts of their present stupidity."

Despite these suggestive remarks, twenty-six years have elapsed without an investigator making a study of the ecology of sleeping insects solely. But here and there are recorded or more often buried under some far-away title some casual notes on the sleeping habits of insects.

The foremost among these are on the most interesting insects from a psychological point of view, the Aculeate Hymenoptera, bees and wasps. Peckhams tell us that the wasp *Astata bicolor*, when she turns in for the night, closes the door behind her until 7:30 o'clock the next morning; then she finishes, fills and seals this nest and begins another which by evening is far enough along to furnish her good shelter for the night, and so on she always plans and executes her day's work so that each evening she has her lodging-place ready for the night.

They also noted that the male *Philanthus punctatus*, which is without a sting and does not assist in nest building, excavates for himself holes to shelter him for the night, covers the opening with loose soil, and returns to the same abode for several nights. They also mention *Pompilus scelestus* hanging to a leaf of a plant four inches from her burrow and there falling asleep until after eight the next morning, and the wonderful industry of *Crabro stirpicola* working at nest-building for forty-two consecutive hours with only a ten minute interruption.

Hartman finds that a day's work of *Odynerus dorsalis* consists of storing a cell, closing it and building another to be used as a sleeping apartment for the night.

Fabre records finding on a mountain some hundreds of *Ammophila hirsuta* assembled under the shelter of a stone. He has speculated much in attempting to account for this gregarious condition of solitary wasps, but in view of the fact that we have recorded similar phenomena in the sleep of *Ammophila pictipennis*, *Chalybion cœruleum* and *Elis 5-cincta*, we cannot interpret his observations other than that the wasps had come together for the purpose of sleep.

These mentions will indicate that the subject is pregnant with possibilities from an ecological point of view, and probably more so from a physiological view-point. The sleep of an organism signifies more than a mere pause in its activity while darkness covers it; while we have not in the present paper touched upon the physiological phenomena of their sleep, we have found many interesting associations of this with the other activities of the insects. For instance, it is of marked biological interest that a few species certainly seem to choose protectively colored situations, and others select sites which are in various ways protective; that some which are solitary by day are gregarious at night, that some insects sleep with all the regularity of a theoretical modern infant, while others of a more unsystematic life snatch a wink when they can. We do not know whether the anemotropism evident in the behavior of some insects is a physiological or psychological phenomenon, or merely mechanical in its origin.

There are many other larger problems that should emanate from a study of sleep, such as the effect of regular or irregular sleep on longevity, the correlation of food habits with the sleeping habits of insects (vegetable feeders more frequently regular sleepers, while carnivorous species are irregular); the correlation of sleep and hibernation, the physiological differences and similarities; the habits of rest of animals in the higher or lower planes of evolution, or the correlation of sleep with the degree of nervous development (*e. g.*, the wasp must provide its own food, build the nest and provision it—a hard life of high mental exertion—while the Dermestes or the bed-bug has no such tasks; hence is the same rest needed for both?)

The sleep of animals in the immature stages, larval, pupal or even egg stage, is something untouched upon, and observation on the sleep of insects that can be kept in confinement, such as roaches, dermestes, meal-worms, etc., offers to the investigator the comfort of the laboratory for his investigation.

In closing let us again say with Scudder: "Only a few of the most patent of tricks and ways of butterflies [insects] have been noted. * * * These are however still too few whereon to base any general statement, * * * and I leave them in the hope of enticing some one to enter a promising field and perchance relieve these facts of their present stupidity."

ANNOTATED BIBLIOGRAPHY.

Adams, C. C. Bull. St. Lab. Nat. Hist. **11**: 110, 119, 140, 193. 1915. Even Noctuid caterpillars such as *Peridroma saucea* and its allies, which live on the ground during the day, climb trees at night. Mentions sleeping habits as recorded by Banks, Brues and Bradley: *Scepsis*, *Chlorion atratum*, *Polistes variatus* and *P. pallipes* sleeping on goldenrod flowers.

Annandale, N. Proc. Roy. Phys. Soc. Edinb. **29**: 439–444. 1900. *fide* Longstaff. He thinks the majority of Malayan Phasmidae are active in the intense heat of midday, when most of their enemies of the jungle are at rest, but remain well concealed in the early morning and late afternoon.

Ashmead, W. H. (Discussion.) Proc. Ent. Soc. Washington **4**: 26. 1896. Noticed wasps in N. Carolina in early morning, but had never seen them asleep.

Banks, N. Sleeping habit of a bee. Ent. News **19**: 340. 1908. A little black bee, *Panurginus illinoiensis* Robt., ♂'s only, have been found asleep; they rest with wings folded close to the body, upon the yellow center of the daisy. They first fell asleep about 6:30 P. M., and by 7:00 many were so soundly asleep that one could frequently pick up a flower containing them and carry it some distance without disturbing them.

Banks, N. Sleeping habits of certain Hymenoptera. Journ. N. Y. Ent. Soc. **10:** 209–214. 1902. Notes on sleeping habits of *Ammophila pictipennis* Walsh, *A. vulgaris* Cress., *Epeolus remigatus*, *A. urnaria* Klug, *Melissodes bimaculata* St. Farg., and *Myzine sexcincta* Fab. ♂'s.

In a field near by a few *Bombus americanorum* were found clinging to the under side of a wild carrot flower, back downward; they did not grasp with their mandibles. *Cerceris kennicotti* was resting under a loose piece of rail. *Halictus lignotus* and *Odynerus conformis* were on grass heads. In New Mexico six *Amegilla smithii* Cress. were asleep, clinging by mandibles to grass stems.

Barrand, ——. Resting Attitudes of Rhopalocera. Entomologist **1906:** 160.

Barth, G. P. Bull. Wisc. Nat. Hist. Soc. **6:** 150. 1908. *Anacrabro ocellatus* Pack. still working at 7:45 P. M.

Bate, D. M. A. Notes on the resting attitude of *Zamacra flabellaria.* Entomologist **36:** 106. 1903. *Fig.* Assumes a peculiar position when at rest, forewings erect above the thorax and at the same time folded like a closed fan. The under wings are also folded, but to a smaller extent and are only slightly raised; the hinder end of the body is also raised. The antennæ lie close along the sides of the body. Quotes Sir George Hampton, Fauna Brit. Ind.: Moths of genus *Gathynia* repose in the form of a cross, with the forewings rolled up at right angles to the body, the hind wings folded close to the body.

Bolle, J., and M. Richter. Studien uber die Ursache der Schlafzucht der Seidenrapue. Zeits. Landw. Versuchs Oest. **1903:** 287. Abstract, Zool. Zentralbl. **1903:** 911.

Brischke, G. A. Ent. Monatsber. **1:** 11. *Psammophila viatica* associated in numbers at the end of September: apparently all females. Fact verified by reviewer in Zool. Rec. **13:** 130.

Benton, ——. (Discussion). Proc. Ent. Soc. Washington. **4:** 26. 1896. The honey-bees when asleep hold to each other in a cluster; the upper ones grasp any projection with the mandibles while the lower ones grasp also with the mandibles and forefeet the legs of those above.

Beutel-Reepen. Die Stammengeschichliche Entstehung des Bienenstaates. Einfamillenstaat. Leben and Wesen der Bienen, 45–66. The ♂'s of several species of solitary bees spend the night congregated in large clusters. *fide* Turner.

Biro Lajos. Szabadban alva mehek es darazok. Ravartani Lapok. **2:** 169–172. 1885. Observations on about twenty species of Hymenoptera while asleep upon *Centaurea urenaria. fide* Psyche.

Bradley, J. C. Gregarious sleeping habits among aculeate Hymenoptera. Ann. Ent. Soc. Amer. **1:** 127–130. In California, June, 1907, a bunch of black wasps, *Priononyx atrata*, were asleep on dried stems of wild oats, in groups of from 2 to 25; 490 were taken in one hour. A week later they were less abundant. (Naturally when 490 were taken). Also *Prinonyx biveloleatum, Sphex* (*Ammophila*) two species, *Monedula emarginata, Steniola duplicata, Stizus unicinctus* and *Sphecius fervidus*, Cr. Associated with them were bees, *Bombus* sp., *Halictus farinosus* and *Melissodes agilis.* He thinks they had previously been scattered over the large field, but had been driven together thus by the recent cutting of the field.

Brues, C. T. On the Sleeping Habits of Some Aculeate Hymenoptera. Journ. N. Y. Ent. Soc. **11:** 228–230. 1903. *Priononyx atrata* along shores of Lake Michigan at Chicago; large number asleep on a large sweet clover. In McHenry Co., Illinois, several species were commingled upon the same plants, viz.: *Epeolus lunatus* a parastiic bee, *Scolia bicincta, Nysson plagiatus, Tachytes* sp. The Texan *Scolia lecontei* chooses a species of Umbelliferæ as its sleeping-place and rests, head downward, upon or below the umbels of the plant. The common *Myzine sexcincta* rests not only at night but in the middle of the day also. In southern Illinois and also in Massachusetts the ♂'s of this species occur in abundance on the dry plant of the wild pink.

Champion, H. G. and R. J. Observations on the life history of *Methoca ichneumonides*, Latr. Ent. Mon. Mag. **50:** 268. 1914. Spends night and dull weather in an empty hole or any dark hollow.

Chapman, T. A. Butterflies at rest. Ent. Rec. **18:** 168–170. 1906.

Cockerell, T. D. A. Ann. & Mag. Nat. Hist. **1900:** 413. Found *Anthidium perpictum* "resting on the stems of grass in dull weather." *Fide* Banks.

Cresson, E. T. Hymenoptera of Cuba. Proc. Ent. Soc. Phila. **1865:** 88. Prof. Poey informs him that *Melissa rufipes* "retires to a bush to sleep, it seizes a branch with its mandibles and places itself in a horizontal position, the back turned toward the ground." *Fide* Banks.

Cresson, E. T. Hymenoptera Texana. Trans. Amer. Ent. Soc. **4:** 201. 1872. Cresson states that Belfrage said that *Scolia lecontei* rests during the night and chilly weather in clusters closely attached to the stems of grass and plants. *Fide* Banks.

Darwin, C. Power of Movement in Plants. Chap. VI and VII. 1896.

Dubois, R. Etude sur la Mecanisme de la Thermogenese et du sommeil chez les Mammiferes. Physiologie comparee de la Marmotte. Ann. Univ. Lyon. pp. 268. *125 pls. 119 figs.* 1896. Not seen.

Eaton, A. E. Aculeate Hymenoptera from Burgos, Old Castile, collected during the total eclipse of the sun, August 30, 1905. Ent. Mag. **42:** 96–98. 1906. *Bombus* and hive bees ceased to be seen, and ants went to sleep on shoots of a yellow-flowered *Ononis*.

Fabre, J. H. The hunting wasps. Tr. by A. T. de Mattos. p. 67, 255. 1915. *Sphex flavipennis* retires into her burrow at night, and also seeks shelter there in bad weather or rests for a few moments during the day. The sandy *Ammophila* and the silvery *Ammophila* do not spend their nights or leisure in their holes, but leave the premises altogether after concealing the entrance with a stone.

Fabre, J. H. The hunting wasps. 1915. Records a single instance of finding on Mont Ventoux, at a height of 6,000 feet, some hundreds of *Ammophila hirsuta* under the shelter of a stone. While Fabre has some difficulty in interpreting this phenomenon, I can only see in it an analogous condition to that recorded for *Ammophila pictipennis* or *Chalybion cæruleum*—viz.: congregating for the purpose of sleeping.

Fabre, J. H. The mason-bees, p. 86, 1914. The mason-bee of the walls, *Chalicodoma muraria* spends the days and nights in one of the cells of her dome, suspended head downwards; the mason-bee of the sheds, *C. siculla*, does very nearly the same as long as there are vacant galleries in her nest, but after these have been used as cells she selects another retreat. The Chalicodomæ pass the nights in the stone heaps in the harmas in numerous companies, piled up promiscuously, both sexes together. The most common dormitory is a narrow crevice between two stones; here they all huddle, lying flat on their backs like people asleep. Should bad weather come on, they do not stir.

Fiebrig, K. Sehlafende Insekten. Jenaische Zeits. Naturw. **48:** 315–364. 1912. See appendix.

Fletcher, T. B. Do butterflies migrate by night? Spol. Zeyl. **4:** 178–179. 1907.

Floersheims, ——. Tutt Ent. Rec. **18:** 36–39. 1906. Description of the great extent to which beetles attack and kill sleeping butterflies. (*Fide* footnote Ent. Soc. Lond. p. cxxi. 1906.)

Fountaine, ——. Roosting habits of *Heliconius charitonia*. Entomologist **44:** 403. 1911. They assemble between five and six P. M. and sleep in clusters. One group of a dozen or so noticed every morning always on the same twig of *Phenox hitrus;* sound asleep at six A. M.

Frohawk, F. W. The Sleeping Attitude of Lycaenidae. Entomologist **47:** 212–213. 1914. It is generally supposed that the Lycænidæ sleep throughout the night sitting head downward on flower heads and grass stems, in the characteristic attitude they assume in the evening, but later when darkness supersedes the twilight the butterflies (*L. icarus*) turn around and sleep head upward. The author and Mr. W. Holland marked and watched groups of these butterflies and found "they were all head downward from 4 P. M. until darkness; in every case they reversed their position to head upwards at dark," which position they retained for the night.

Garner, R. L. (Abstract.) Science **42:** 843. 1915. The African anthropoid apes sleep on their backs like men, and make their beds eighteen or twenty feet above the ground.

Gill, ——. (Discussion). Proc. Ent. Soc. Washington **4:** 26. 1896. Fish when supposedly asleep are simply quiescent with their fins waving at intervals or entirely still. African *Dipnoan protopterous*, when streams dry up, goes into the mud, makes a cocoon of slime surrounded by mud, and in this condition has been carried to Europe and revived by placing it in water and dissolving the cocoon.

Green, E. E. Sleeping Habits of a Bee. Ent. Mon. Mag. **1899:** 214. Not seen.

Hartman, C. Observations on the Habits of Some Solitary Wasps of Texas. Bull. Univ. Tex. No. 65: 7. 1905. A day's work of *Odynerus dorsalis* consisted of storing a cell, closing it and building another before evening to be first used as a lodging place the following night and filled the next day. (Hartman, in a letter, says he suspects this species has been erroneously identified for him.)

Hine, J. S. Techn. Ser. U. S. Dep. Agr. Ent. No. 2, pl. ii, p. 24, 1906. The autumn horse-flies, *Tabanus sulcifrons* Macquart, are most active in the strongest sunlight. As evening approaches they become less active and seek a resting-place among the foliage, on some tree-trunk, or on a fence where they remain quiet until sunrise. They have a tendency to collect at evening in certain favorable places in large numbers, ♂'s and ♀'s together.

Hoffmann, F. Wie und wo nachtigen die Tagfalter? Mitt. Polyxena Wien. **6:** 1. 1911. (Not seen.)

Ingersoll, E. Life of animals. p. 313. Quotes Perry, on the Wapiti deer: "If there is a stream running through the valley, bordered by a sand bar, the entire band makes this their sleeping place, and the band always assume the same position in sleeping—the calves, cows and yearlings in the center, and the bucks around the outer edge of the circle, so that in case of a night attack by wolves or panthers the strongest will meet the first onset of the foe."

Isely, D. The Biology of Some Kansas Eumenidae. Kans. Univ. Sci. Bull. **8:** 243, 299. 1913. Quotes Hartman on *O. dorsalis* in reference to its using each newly constructed cell for a night's shelter. Scoliids and Ammophilæ and a solitary *Eumenes bolli* would collect for the night on the tall prairie grass in Ness Co. *Eumenes* did not hold its body rigid as did *Ammophila*, but held itself at right angles to the stem with its abdomen curled under it.

Jensen-Haarup, A. C. Maerkvaerdig Sovestilling hos hannes af visse Bier. Kobenhavn Flora og Fauna 1909: 65–67. A remarkable position during sleep among the males of certain bees. (Not seen.)

Kearton, R. The Fairy-Land of Living Things. Where birds sleep. pp. 58–61. 1908. A popular account.

Kolbe, W. Ueber das Eintreten des Sommerschlafes bei den Chrysomeliden. Zeits. Ent. Breslau **24:** 26–57. 1899. Not seen.

Longstaff, G. B. Some rest-attitudes of butterflies. Trans. Ent. Soc. Lond. **42:** 97–118. 1906. *Lycæna icarus* asleep on the heads of grasses; 12 out of 15 had head down. Most butterflies when asleep usually close their wings over their backs, but some of the larger skippers such as *Caprona* probably sleep with them spread out like geometers. The common skippers *Pamphila sylvanus* and *P. linea* adopt the usual butterfly attitude, but Roland Trimen called attention to the fact that *Nisoniades tages* L. sleeps with the wings inclined so as to form a roof, like many Noctuæ, (Barretts Lepid. Brit. Is. 1: 309.) *G. rapæ* when settled for the night makes no effort to resist capture. *G. brassicæ* goes to sleep on hawkweed, etc., at 7:15 P. M., and remains with wings hanging down and closed over its back.

Martineau, A. H. Entomologist **29:** 268. 1896. *Sapyga clovicornis* when at rest, "lays its big clubbed antennæ between its legs along the under side of its body and quite out of sight, the clubs being turned upwards at the end."

McCook, H. C. Nature's Craftsmen. pp. 64–67. 1907. The toilet operations of ants usually precede and follow sleep. Their sleepy ways may be illustrated by a group of 25 or 30 agricultural ants. They had been lured by a gas lamp upon the table from underground galleries in a glass formicary. They grouped themselves in little clusters next to the light, on top of corks, clods or pebbles placed for them, for they like slight elevations. Most of them cuddled upon the surface, some squatted upon their abdomens, some lay upon their sides, some stood tiptoe on their hind legs, some crouched upon the earth, piled

high one atop the other. There was constant agitation in the clusters, and frequent changes of position. While the ants of one group were sleeping, others would be at work, and these at times would vigorously jostle the sleepers. New members occasionally joined a group and in their eagerness to get close up to the heat, crowded their drowsy comrades aside. Ants at work in the galleries would drop the pellets they carried, push into a group of sleepers and presently be sound asleep themselves. The longest period during which individuals were observed to sleep was three and a half hours.

Minot, C. S. Notes on the Flight of New England Butterflies. Proc. Bost. Soc. Nat. Hist. **14:** 55–56. 1870. The postures of the butterflies by day are all different from those assumed by night. A little before sundown *Colias philodice* Godt. and *Pieris rapæ* Shrank, begin to alight in the grass. "As it gets later they become more and more inactive until finally they will allow themselves to be trodden upon, pinned and handled in any way. Before twilight is ended they creep down, or descend in some manner, I do not know how, to the very roots of the stalks or blades of grass." They always choose a perpendicular stalk, the wings are raised over the back, the outer edges pressed together, the antennæ are kept nearly perpendicular to the axis of the body and almost concealed by the front edges of the wings.

Morley, M. Wasps and Their Ways. p. 120. 1901. Hornets have been known to work by moonlight. Captive wasps are unable to sleep with a light near by.

Noyes, A. A. Biology of the nest-spinning Trichoptera. Ann. Ent. Soc. Amer. **7:** 269. 1914. Many Trichoptera larvæ build their dwellings chiefly during the night, but *Hydropsyche* build their tubes and nets at all times of the day or night.

Oudemans, J. T. Etude sur la position de repos chez les Lepidopteres. Verhandel. Kon. Akad. **10:** No. 1. 1904. *Fide* Longstaff. "Lepidoptera have a sleeping dress; this dress forms a harmonious whole. The different parts which contribute to form the whole dress harmonize in their colors and usually in their patterns. The parts of the insect which are concealed during rest are quite frequently strongly contrasted in color or pattern to the exposed parts."

Peckham, G. W. and **E. G. Peckham.** Instincts and Habits of Solitary Wasps. Bull. Wis. Geol. and Nat. Hist. Surv. Ser. 1. **2:** 94. 1898. At 4:15 *Astata bicolor* thought she had worked long enough, went into her hole, closed the door behind her and remained there until 7:30 the next morning. She began the work of excavation in the morning, carried it on without haste or pause until 2 or 3 in the afternoon and retired at about 4 o'clock; the next morning she completed the nest in about an hour. They also saw this species make a shallow temporary hole for the night. When the weather was cold or cloudy *Philanthus punctatus* Say remained closely housed within the nest. Two ♂ *P. punctatus* excavated a temporary hole for shelter for the night, covered it with loose soil, remained in it from about 4 o'clock until 10 the next morning, peeping out only once at 8:30 to look around but again retreating and closing the door. ♂'s do not construct a new lodging every night but return to the same spot to sleep. Other wasps creep into crevices; often found in holes in posts. "But we are glad to put it to the credit of one ♂ that he had sufficient foresight and industry to provide a sleeping-place, and sufficient intelligence to return to the spot when the declining sun warns him that evening is approaching." Two *Crabro stirpicola* Pack. worked at nest-building without cessation throughout the night, the second day and second night—a period of forty-two consecutive hours with only one intermission of ten minutes. At 4 o'clock *Pompilus scelestus* Cres. began to investigate very carefully the plants and grasses immediately surrounding her hole; she selected a bunch of clover four inches away, and hanging to a leaf she remained motionless and fast asleep until they left her at sundown. The next morning at 8 o'clock she was still soundly asleep. After they had gently aroused her, she crept up the stem, stretched herself sleepily and slowly made her toilet.

Peckham, G. W. & E. G. Wasps, social and solitary. 1905. Female *Crabro* like those of other genera seem to use the galleries of their nests as sleeping places, but the ♂'s stop at any convenient inn. One was entertained in a hole in one of the porch posts for several nights. *Philanthus* ♂'s spend time and care in digging a hole in the ground to which they return night after night. In *Agenia* the ♀ keeps one cell ahead of her needs and tucks herself away in it very comfortably, but the *Pelopæi*, instead of making use of their tubes, congregate in the evening about convenient crevices. Quote Banks on *Ammophila* and Brues on *Priononyx*. They also observed a *Pompilus* to take the greatest care in selecting a sheltered spot under some leaves where she afterwards hung herself up and slept soundly until 8 o'clock the next day.

Pictet, A. L'instinct et le sommeil chez les insectes. Arch. Sci. Phys. Nat. iv. **17:** 447–451. 1904. (Not seen.)

Poulton, E. B. Predaceous insects and their prey. Trans. Ent. Soc. Lond. **42:** 374, 664. A female *Asilus crabroniformis* asleep on a head of *Centaurea scabiosa*, strongly suggested a crumpled leaf which had fallen upon the flower. This cryptic resemblance was brought about by a remarkable attitude, the insect being in the position formed by a half somersault arrested when the ventral surface was uppermost. *Volucella inanis* readily takes flight in the sun, but in the evening it becomes semi-torpid, and if disturbed then it raises its first leg in a manner clearly mimetic of the warning attitude of its Bombus model.

Rau. P. The sun-dance of the saw-fly. Ent. News **27:** 274–277. 1916. *Macrophya sp. nov.* at rest, apparently settled for sleep, on top of box-elder leaves, before 6 P. M. on an April evening.

Rau, P., and **N. Rau.** The Biology of the Mud-Daubing Wasps. Journ. Anim. Beh. **6:** 27–63. 1916. The mothers themselves (*Trypoxylon albitarsis* Fab., *Sceliphron cæmentarium* Drury and *Chalybion cæruleum* Linne) do not use their mud nests for their own shelter but go elsewhere for the night. *Osmia cordata* when removed from its cell prematurely would creep back into its old cell or be happy to get into any crevice.

Rau, P. & N. Rau. A sleepy Eumenid. Ent. News **24:** 396. 1913. At night the *Ancistrocerus unifasciatus* Saus. would creep into the old cell of the mud-daubers' nest from which they had emerged. In keeping *Pelopoeus cæmentarium* of both sexes in cages with the nests from which they had hatched no such behavior was ever observed.

Read, C. Instinct, Especially in the Solitary Wasps. Brit. Journ. Psychol. **4.** Pt. 1. Mentions sleeping habits of wasps from Peckhams' account.

Roubaud, E. The Natural History of the Solitary Wasps of the Genus Synagris. Smithson. Rept. **1910:** 507–524. The nests of *Synagris sicheliana* are masses of yellow earth; the most recent cell is always open and serves as a shelter for the builder, which very often dies in it. *S. cornuta* L. during rare moments of rest and at night remains in her cell with her head turned outward, guarding her young.

Sanborn, F. G. Proc. Bost. Soc. Nat. Hist. **12:** 98. *Ammophila gryphus* clasping small oak twig with mandibles and feet body elevated one-fourth inch above twig. *Fide* Scudder and Mann.

Saunders, ——. Hymenoptera Aculeata of the British Islands. p. 308. The ♂ of *Chilostoma* (a bee) usually spends the night curled up in flowers, but Smith says that at other times he has observed them hanging to blades of grass by their mandibles. *Fide* Banks.

Schwarz, E. A. Sleeping Trees of Hymenoptera. Proc. Ent. Soc. Washington **4:** 24–27. 1896. In southwestern Texas *Melissodes pygmæus* Cress., and *Coloptera wrightii* Cress. were abundant and asleep on *Celtis pallida* on the thinnest and outermost twigs and on the stout thorns, sleeping singly, the tips of the mandibles inserted in the wood and all six legs grasping the twig. Four shrubs near together bore 50 to 70 sleeping bees, and several other shrubs had small numbers. They were on these shrubs every morning. The habit reminds one of the well-known "butterfly-trees" of Monterey, California, and Appalachicola, Florida, the sleeping habitats of *Danais archippus* during their winter migration to southern localities. (No reference to the "well known" butterfly trees could be found.)

Scudder, S. H., and **B. P. Mann.** Attitudes in which some Wasps are supposed to Sleep. Psyche **2:** 40–41. 1877. *Ammophila gryphus?* rests at night by seizing grass with jaws and holding itself extended with or without use of middle and hind feet. *Odynerus?* seized twig with jaws and supported body in horizontal position.

Scudder, S. H. Butterflies of Eastern United States. **2**: 1602–1604. Cambridge. 1889. Postures at rest and asleep. At sleep the wings are packed away into smaller compass, with the exception of some Hesperidi; the wings erect back to back, the forewings slide down behind the hind pair so that only the latter and the apex of the front edge of the former are visible. One observation of a European *Thais* asleep in confinement with spread wings. There is more variety in the position of antennæ; some like Satyrinæ sleep with these spread wide, others tuck them between the wings, and others bring them together beside the front edge of the wings the clubs appearing beyond as if crowded out by the tight shutting of the wings.

Severin, H. H. P., H. C. Severin and **B. S. Hartung.** The ravages, life history, etc., of the melonfly, *Dacus cucurbitæ.* Ann. Ent. Soc. Amer. **7**: 191. 1914. Feeds from sunrise to ten o'clock, but during the hottest part of the day thousands may be found at rest under large leaves of plants in or near an infested field of cucurbits.

Shepheard-Walwyn, Entomologist **36**: 201. *pl. 3.* 1903. The resting position of the moth, *Plusia moneta* is most striking as it hangs by its two front legs, stretching them out to their fullest extent.

Sladen, F. W. L. The humble-bee, p. 63, 267–268. 1912. A humble-bee is usually in an animated state, abdomen pulsating, head held erect and antennæ pointing at attention, but occasionally a queen is found resting on a flower with her head hanging down and antennæ resting on her face, evidently indulging in a nap, for she awakes with a start when disturbed. Before the cares of motherhood have come upon her the queen is very fond of dropping off to sleep in the warm sunshine or in the newly found nest. *Psithyus*, the usurper-bee, becomes a temporary lodger in the nest of *Bombus*, returning to it for meals and to spend the night.

Slevogt, ——. Haben Insekten Ortsinn? Soc. Ent. **19**: 37. *Aeschna* has permanent night quarters. (Not seen.)

Soule, C. G. Sound Sleep of *Lycaena americana.* Psyche **5**: 42. 1888. She observed in the vacant lots about Boston "that as one side of the street grew shady toward sunset *L. americana* might be seen clinging to grass blades with wings somewhat drooped, suggesting that the muscles were somewhat relaxed by sleep." One was carried on a grass stem five blocks undisturbed. Later experiments always found the butterfly in the same position more than half way up the grass-blade, head up, wings drooped to an acute instead of a right angle with the body.

Stiles, C. W. (Discussion.) Proc. Ent. Soc. Washington **4**: 27. 1896. It is difficult to conceive of the sleep of a tape-worm, *Oxyurus;* yet it undoubtedly has long periods of rest and is active in the evening. Many protozoa are still for a long time; *Acalephs* have also a resting period; in necrobiosis sleep may last for eight or ten years.

Tonge, A. E. Resting attitudes of Lepidoptera. Proc. S. Lond. Ent. Soc. **1909**: 5–8. *Pl. 2–3.*

Turner, C. H. Literature for 1914 on the Behavior of Spiders and Insects. Journ. Anim. Beh. **5**: 439. 1915. Reviews Beutel-Reepen on sleep of solitary bees, Williams on *Priononyx thomæ* and Frohawk on butterflies of the family of Lyncænidæ.

Turner, C. H. Notes on the Behavior of a Parasitic Bee of the Family Stellidæ. Journ. Anim. Beh. **1**: 374. The bees hatched from a nest of the mud-dauber, and at night or whenever the room was darkened the bees would retire to the mud cells.

Vavilov, ——. Quoted in Journ. of Hered. **7**: 43. 1916. Wild geese "swim to the selected open shore, where they get out, lie down, and fall asleep. The old birds alone do not sleep, but divide the watches, and, if they hear anything suspicious, at once wake the whole flock with a loud cry of warning."

Watson, J. B. Behavior, an Introduction to Comparative Psychology. p. 112. 1914. Night and day periods of activity are purely instinctive, since no structural peculiarities account for the differences.

Watson, J. B. Journ. Anim. Beh. 2: 431. 1912. Quotes Werner (Biol. Centralbl. **31**: 41–44.) on sleeping habits of fishes, *Amiurus nebulosus*, *Misgurnus fossilis* and *Cabitus talnia*. The bodily attitudes taken in sleep are quite different for different species, even in nearly related species. In general there is a complete cessation of activity, a certain chosen bodily attitude and almost complete stoppage of breathing. Very light contact is sufficient to awaken the fish.

Werner, F. Ueber die Schlafstellungen des Fische. Biol. Centralbl. **31**: 41–44. Reviewed by Watson.

Westwood, J. O. Introduction to Modern Classification of Insects **2**: 211. 1840. *Scolia interrupta* and *S. 4-punctata* ♂'s, which are extremely sluggish, are found crowded on the ears of grass near the seaside, in groups or socieites of 20 or 30 where they pass the night and make no attempt to escape. The ♂'s of *S. 6-cincta* are found in similar localities. Quotes from Latreille that in night or bad weather *Fœnus jacubator* fix themselves by their jaws to the stalks of different plants and are then almost in a perpendicular position.

Williams, F. X. Monograph of the Larridae of Kansas. Kans. Univ. Sci. Bull. **8**: 187. 1913. Larridæ ♂'s make holes probably as a place of retirement during unfavorable weather and at night. A black species of *Tachysphex*, probably *fuscus* or *terminatus* was observed digging a hole in the sand and closing the retreat from within. *Plenoculus apicalis* and *Niteliopsis affinis* have much the same bahits as the above.

Williams, F. X. Larridae of Kansas. Kan. Univ. Sci. Bull. **8**: 210. 1913. The males of the Larridæ are "frequently seen on flowers or basking in the sun. They were only observed to work when excavating short tunnels, in which they probably passed the night."

Williams, F. X. Notes on the Habits of Some Species of Wasps that Occur in Kansas. Kans. Univ. Sci. Bull. **8**: 227. 1913. *Priononyx thomæ* ♂'s in common with many other species of Sphegidæ congregate in some numbers on weeds where they pass the night or remain during unfavorable weather. Such "clumps" are common on Russian thistle in western Kansas.

Wittfield, ——. The southern *Euphoeades palamedes* sleeps with spread wings. *Fide* Scudder.

APPENDIX

From a physiological point of view the concluding remarks by Fiebrig are suggestive, and we here append an English translation of that part of his paper, pp. 347-354.

Those characteristics, which are manifested in the true sleep of vertebrates, are also present in the sleep of insects, especially of the Hymenoptera. These characteristics are principally:

Relative immovability,
Unconsciousness,
The same or similar behavior under various external influences (light, approach, contact),
Similar behavior when going to sleep and on awaking,
Adjusting of the periods of sleep to the changing periods of day and night,

in short, very often, manifestations which lead to the conclusion that the habits of sleep are protective. But, while most of the remaining accompanying manifestations, as, for instance, the response to external stimuli, seem to correspond to those well-known and familiar forerunners of sleep, the specific rigidity among insects of the (cataleptic) muscular strain is just the opposite of our usual conceptions of sleep. To be sure, we recognize certain sleep-like manifestations, which at present are causing much discussion, resulting from hypnotism, often bringing about most surprising results, and, just as among bees, showing the strangest departures from normal rest positions. We also speak of an hypnotic sleep, a rigidity brought on by hypnotism. We do not understand as yet the physiological processes of these cataleptic conditions observed among vertebrates. Do similar physiological processes exist in the sleep of insects, in the clinging colonies of bees and wasps, as take place in the hypnotic sleep of vertebrates? It is a well known fact that not only man is susceptible to this form of sleep, but also many, psychologically poorly developed, vertebrates, as, for example, the hen. Is perhaps this hypnotic-like sleep of insects the forerunner of our present fully developed form of sleep, in which, because of the high development of the psychological, i. e., the nervous system, the assimilating and reviving processes are more complete and radically more intensive? Such cataleptic or hypnotic sleep in the higher vertebrates could be regarded as an atavic form of sleep. This view would receive considerable support if we were to assume that such a sleep was the rule among cold blooded animals of the present day and particularly among the giant lizards and amphibians of prehistoric ages. The fact that this so-called "hypnotic" sleep is of a decidedly passive nature and only brought about through the influence of an external organism need be regarded of only secondary importance for our comparison, in which the cataleptic manifestations accompanying sleep are the vital considerations; it can readily be assumed that among insects instead of a person an object, i. e., any external factor, to a certain extent could act as hypnotizer (for example, light or its absence.)

Although we may compare the manifestations of sleep among insects with a known form of sleep, we have not advanced very much further in knowing its nature, particularly so, since the physiological nature of hypnotic sleep is, I believe, still unknown. It would be carrying me too far were I to consider—even speculatively—these apparently most complicated manifestations further. One thing I should like to call attention to particularly, however, and that is the significance of the organs of sight. Sight seems to be the sense which is most intensely affected by sleep, judging from the susceptibility of a sleeping organism to light stimuli, particularly the dependence of sleep on the amount of light. We are forced to the conclusion that it is the optic nerves which usher in sleep, which perceive and transmit the first intimation of sleepiness, which give the body the signal that it is time to retire. (Just think of the drooping eyelids of tired persons.) The same is true, as we have seen, of the sleep of insects. On comparing the organs which bring this about—the eyes—which transmit the sleep producing sensations, we find a very material difference. On the one side we have the one lens eye (closed by means of a lid) of the vertebrates, and on the other the facet eye of the insects. Are these differently constructed organs of sight in any way connected with the variations in sleep manifested by these two widely separated groups? Picture the effect of light, positive or negative, on insects, and its effect on the nervous system of the articulates with relatively few ganglia: many eyes and few nerve cells opposed to one pair of eyes and a single nerve center with a highly diversified nervous system among mammals and birds. Would it not be conceivable that, since sleep manifestations are so closely connected with the eyes (the optic nerves), they would assume certain definite forms according to the kind and construction of the organs of sight? According to my judgment all the great variations in the organization* of the widely differing groups of animals which are expressed in various forms of sleep, also cause the various uses of the limbs, especially of the muscles; we have only to call to mind the great difference in the sleep of warm and cold blooded vertebrates, which, undoubtedly, is caused primarily by a difference in respiration, i. e., conditions of blood circulation. The manifestations, which among cold blooded vertebrates have a certain resemblance to sleep, are so different from those conditions among mammals and birds, not even a sensitiveness to light seeming to be present, that it is doubtful whether among cold blooded animals conditions occur which can be designated as "sleep" at all.

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*It would perhaps be simplest to ascribe the specific manifestations of sleep among insects to the little developed circulatory system.

It must seem very peculiar, indeed, that, while we are unable in general to recognize an ability to sleep among cold blooded vertebrates, the nearest relatives of the sleep-demanding mammals and birds, we should have for so large a number of the much lower articulates such convincing evidence of a sleep similar to that of the highest organized animals. As far as my investigations have gone this seems to be the case, the sleep of insects appearing to be real sleep, while those sleep-like conditions which are found among cold-blooded vertebrates, can hardly be admitted into the catagory of actual sleep manifestations. Startling as these conditions may seem at first glance, upon reflection some of their surprising effects become clearer when we recall how totally different is the distribution of the physical and the psychological qualities in these widely separated groups.

In conclusion I wish to call particularly to mind that among warm blooded animals those seem to have the most pronounced form of sleep which have the intensest manifestations of life (particularly again the birds). With such intensive living the busy workers certainly deserve a few hours of rest; we can surely appreciate their intensive desire for rest, and that insects also "get tired and sleep."

Sleep is a reflex of life, indeed, of the active manifestations of life, the reflected image of the physical and psychological activity of an organism. From this point of view we shall be able to understand more clearly certain forms of sleep. In the same way we shall be helped in explaining also the sleep of insects, the richest group in genera in the animal kingdom, which we meet at every step and whose existence, whose lives are still so little known to us.

REDUCING MALARIA BY REDUCING THE NUMBER OF ANOPHELES WITHIN BUILDINGS.

By James Zetek,
Entomologist, Rep. of Panama.

Malaria may be entirely eliminated and in time become an unknown disease. But to achieve this desired end soon, calls for unprecedented co-operation extended over a very large territory, and it would require vigorous anti-malarial work for many years. The cost of such work will be very heavy, however, an investment as great, if not greater, than the Panama Canal. The lives and time saved by such eradication, and the increase in energy and longevity which would follow, expressed in dollars and health, would soon repay with interest all that had been spent. A campaign such as this could, with very little additional cost, eliminate a few of the other insect-born tropical diseases.

The purpose of this paper is to show how in a given camp malaria may be greatly reduced by the reduction in numbers of the *Anopheles* which gain entrance into buildings. By *Anopheles* I mean those species only which are known to or are supposed to transmit malaria. It is essential, therefore, to become acquainted with the mosquito fauna of a given region and learn which members of it are pathogenic. The observations recorded herein were made at MiraFlores construction Camp, Canal Zone, at which point are the last two flights of locks to the Pacific entrance. The buildings of this camp are of similar size and shape, located in straight, parallel rows. This uniformity in design and position made the interpretation of our data easy. The following sketch aims to give all the essential data regarding MiraFlores camp. All doors are indicated excepting such as lead only to screened-in porches. The symbols used signify: W-I—West Indian negro; S—Spaniard and other European; C—Columbian and Panamanian; E-I—East Indian (Hindoo); W—white American. Unmarked buildings are offices, stores, schools, hotel, police station, etc. Dots represent position and number of insect traps affixed to the buildings. All doors, windows, etc., are well screened with 18-mesh copper wire screen, and cracks and holes in floors are stopped-up as well as could be expected. The site of the camp is at present under the waters of MiraFlores Lake. The observations reported were made in the year 1912. I am indebted to Messrs. Shropshire and Chiddester for aiding me considerably at this station.

There were only five possible sources for extensive *Anopheles* breeding, and regular (almost daily) inspections were made of the entire territory to locate *Anopheles* breeding. The only *Anopheles* found to be predominant in the mosquitos caught in the camp was *A. albimanus* Wiede., and excepting during the dry season (Jan. to Apr.), when *A. pseudopunctipennis* Theob. appeared in sparce numbers, was practically the only Anophelene represented in these catches. During the first six months of 1912, only one *A. apicimacula* D & K, one *A. argyritarsis* Rob-Desv. and two *A. malefactor* D & K were caught. The only extensive breeding of *A. albimanus* occurred in the winding Rio Grande, south-west of MiraFlores camp. The five possible breeding centers were: 1, Rio Grande; 2, Rio Cardinas; 3, Rio Cameron; 4, Cocoli water reservoir, and 5, the ditch in the Canal Prism. During the dry season the Cameron river was an unusually favorable habitat for *A. pseudopunctipennis* and *Uranotœnia geometrica* Theob., but no influx of these species was ever noted in MiraFlores. By means of liberating

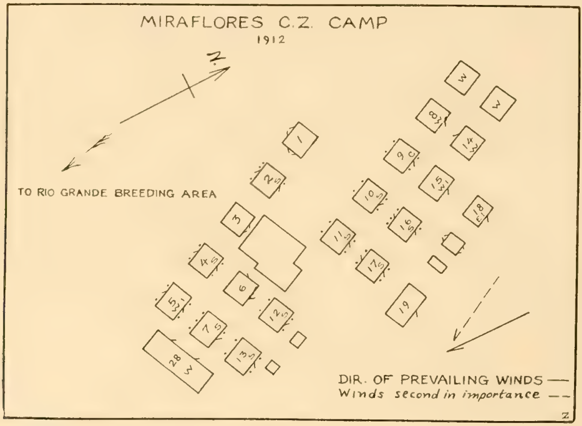
MIRAFLORES C.Z. CAMP
1912
N
TO RIO GRANDE BREEDING AREA
DIR. OF PREVAILING WINDS ——
Winds second in importance – –

Figure 1

at these and other stations mosquitos sprayed with aquaeous anilin dyes, it was determined that the big influx of *albimanus* came from the extensive breeding area in the Rio Grande. The data concerning flight is reserved for a future report.

Exact counts were made of the mosquitos caught in traps and inside of houses; these counts are differentiated as "trap catch" and "hand catch" respectively, and are further divided into two groups, "Anopheles" and "Culex spp," the latter representing all non-anophelinæ. All counts were made daily, but in the results presented in this article, this data is greatly simplified. The trap catch represents those mosquitos which entered the Chas. H. Bath type of insect trap affixed to buildings. This trap is described in my previous paper (Ann. Ento. Soc. Am. vol. VI No. 1). These traps were placed on the sides facing S-W and N-E. The method of catching mosquitos inside of barracks is also described in my former paper. Although the cheapest labor was used, W. I. negroes, this work could hardly have been done better.

EFFECT OF TRAPS AFFIXED TO BUILDINGS ON THE NUMBER OF MOSQUITOS WHICH ENTER THE BUILDINGS.

Two buildings were used to determine this influence. The following table gives a comparison of these two buildings:

Camp 5.	Camp 15.
Contains 75 W-I negroes.	Contains 75 W-I negroes.
Two doors opening to exterior.	But one door opening to exterior.
Four traps.	No traps.
Nearest to breeding area.	Farthest away from same.
Of total mosquitos caught in both camps, this camp's share was but 33%.	Of this same total, this camp claimed 67%.

This comparison shows that both buildings are practically the same, excepting that one has traps while the other has none. The building farthest away from the breeding place, and with but one door, had 67% of the total mosquitos caught in the two camps.

The record was kept of the cases of malaria reported from each of these camps. During the 175 days representing this record, 29 cases came from camp 15 (without traps) and but 12 cases from camp 5. It may be said that there is no conclusive proof that these cases had their origin from the mosquitos present inside of the barracks. But granting this, it surely appears that in two camps so nearly alike we ought to expect about the same number of cases in each. The increase of 250% in camp 15 is due to the fact that on account of no traps, more mosquitos entered the building, and therefore the higher malarial rate.

The weekly summary for these two camps is represented in the following chart. The weekly index was gotten at in the following manner. If during the week twelve collections were made in camp 5, then the total mosquitos (anophelene only) caught in that week were divided by twelve. This gave an average per one catch per week. The same was done with camp 15. Then the average catch of both camps for the same week was added together and considered as 100%. The following notes should be read in connection with the curve. That portion of the chart included within the series of arrows represents data for camps 5 and 10 for during that time camp 10 was used as a W-I barrack. Both camps had four traps each, but camp 10 had but one door while camp 5 had two. Very often extreme fluctuations are due to existing cracks in the floor

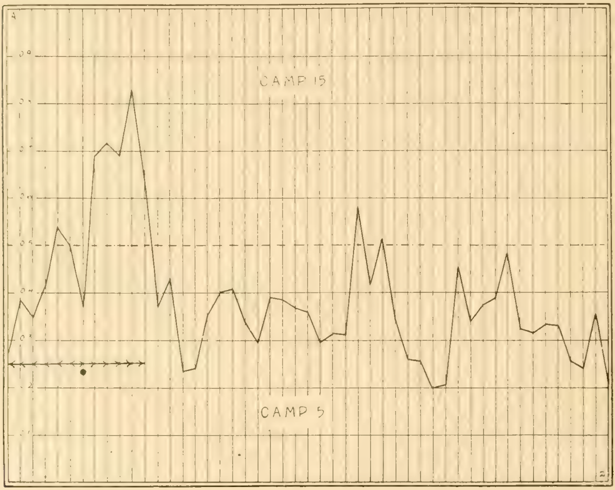

CHART A

through which Anopheles may enter. This is well illustrated by the behavior of the curve at the point marked by a black disc. At this period all cracks in camp 10 were stopped-up. Note the sudden up-shoot of Anopheles in camp 5 due to this. Up to this period the cracks present in camp 10 were the equivalent of an extra door. The remainder of the chart is for camps 5 and 15, and the curve is almost as significant as the familiar campaign literature advocating vaccination against small-pox.

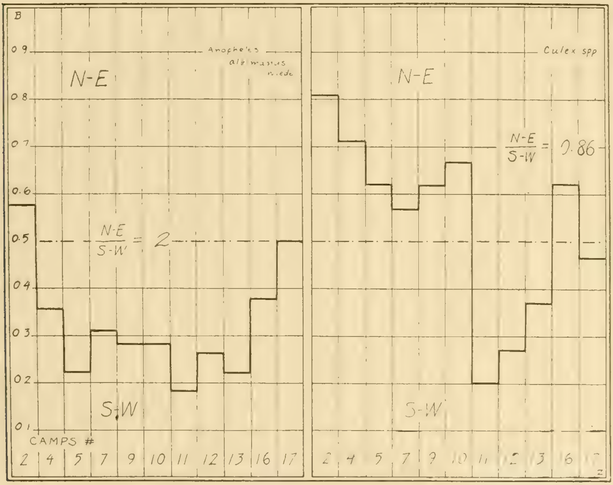

Chart B

PECULIARITIES OF TRAP CATCHES.

Eleven of the buildings of MiraFlores camp had insect traps attached to them. Chart B presents a comparison of the trap catch of the north-east and south-west sides of each building. The percentages were arrived at the following manner: the total number of *Anopheles* caught during the nine weeks from Jan. 29 to Mar. 30, 1912, in the S-W traps were divided by the number of traps to give an average per trap. The same was done for the N-E traps. . The total of these two averages in each building was taken to represent 100%. The record for each building was differentiated into *Anopheles* (almost wholly *albimanus*) and Culex spp. (non-anophelinæ). The Anopheles curve shows double the number of these mosquitos in the N-E traps. There appears to be no discrimination as to nationality of the inhabitants of the several buildings. Emphasis is placed upon the fact that north-east traps contained the bulk of the anophelenes. Reference to the map shows the relation of wind direction to position of traps. The *Anopheles* did not enter freely the S-W traps because this entailed flying against considerable wind. The bulk of these mosquitos flew around the lee side and entered the N-E traps. This preference for the lee side of houses was noted in every case where traps were present. It therefore follows that entrances to buildings should always be on the windward side and not on the lee side.

The culex curve shows conditions opposite to that for the anophelenes. There is no doubt whatever that the culex breeding in the caison to the west of the camp supplied the influx of culex, and being more powerful fliers, did not find themselves forced to seek a wind-protected side. I have no positive evidence of actual flight or even gradual infiltrations of culex from the Cameron River northeast of the camp.

PECULARITIES OF THE HAND CATCH DUE TO NATIONALITY OF THE INHABITANTS.

At first thought it appears improbable that the particular nationality may influence the number of mosquitos that gain entrance into the building. The following table is presented to show what influence was observed at MiraFlores camp.

TOTAL PER FOUR WEEKS' PERIODS, HAND CATCH.
(Avr. per one camp, 1912.)

FOUR WEEKS ENDING	SPANIARD	COLUMBIAN	WEST INDIAN	EAST INDIAN	TOTAL
February 24	459	959	477	75	1970
March 23	434	892	357	42	1725
April 20	486	1274	353	31	2144
May 18	2321	3252	1781	410	7764
June 8 (Only 3 weeks)	1140	2724	1453	422	6139

AVERAGE PER DAY, SAME PERIODS AS ABOVE.

	20.	34.3	20.5	2.7	77.5
	19.	32.	12.7	1.5	65.2
	17.4	45.5	12.7	1.1	76.7
	83.	116.	63.6	14.6	277.2
	54.3	129.7	69.1	20.	273.1

All barracks were of about the same size, type, and held about the same number of people each. Yet the Columbian camp had a much larger percentage of mosquitos than any other camp, and were it not that it had four traps, the amount of mosquitos would more than be double. To understand this pecularity, it is necessary to understand the peculiar behavior of these several types of people, and I briefly outline the more important of these peculiarities. The Spaniard as a rule prefers to lounge outdoors until quite dark. The door to his barrack is practically closed during dusk, the period of maximum mosquito (anophelene) activity. The West Indian is much like the Spaniard in this respect. The Columbian, on the other hand, is much more restless, goes in and out of his camp during the hours of dusk with much frequency and often leaves his doors wide open. The East Indian stays inside of his barrack almost exclusively. Therefore the entrance to his home is kept closed most of the time. Constant opening of doors during the period of dusk, particularly doors on the lee sides of buildings, will admit large numbers of malarial mosquitos.

The malarial rate for the four types is given in the following comparative table.

MALARIA STATISTICS, JANUARY 2 TO APRIL 27, 1912.
(17 Weeks.)

A. Population.

Spaniards	503
Columbians	60
West Indians	102
East Indians	47

B. Malaria Data.

	Total Cases	Avr. Num. per Week	Num. per 100 Sick per Week
Spaniards	153	9.2	1.85
Columbians	11	0.7	1.18
West Indians	44	2.6	2.55
East Indians	2	0.1	0.21

The East Indian (hindoo) is the one with the least malaria, due not to immunity, but becasue of his habit of staying indoors during dusk. Economically considered, the hindoo is the least expensive type of labor, considering cost of hospital treatment. The Spaniard and West Indian, roaming outdoors during dusk, when anophlenes are most active, and being quite susceptible to malaria, show the biggest percentage of cases. The Columbian, native of the region and a veteran of malarial attacks, although his camp has the most malarial mosquitos, shows less fever than the Spaniard. This low percentage is due to a partial immunity "earned" through several previous attacks. I mean by partial immunity more particularly the absence of high fevers; the majority of the laborers whose blood teems with crecents but have no fever, do not present themselves for treatment. Only those cases which come to the office of the District Physician enter our statistics. Another interesting peculiarity is observable; although the Spaniard is more susceptible to malaria than is the West Indian, his rate is lower. This is due to the fact that the Spaniard makes liberal use of the liquid quinine freely dispensed at the messes and places of work, thus reducing and eliminating much malaria. The Spaniard looks upon malaria as just so much money lost; the West Indian is of a much livelier nature, not caring if he is losing money.

No few cases of malaria among the West Indian are repetitions, i. e., a recurrence of the fever after the patient left the hospital. Our hospitals cannot take care of malarial cases for a period longer than after the fevers subsided and the blood smears reveal no crecents or but a few. The patient is always advised to continue quinine treatment for at least a month after dismissal. It should be made clear that the figures presented are for the dry season period, and do not include the high increase in malaria from May to November, and hence may be considered as true indexes of actual susceptibility.

SUMMARY.

The observations reported are applicable largely to temporary construction camps in malarious regions, and unless permanent settlements are in view, screening, traps and mosquito catching indoors will suffice to keep malaria at a very low rate. However, a certain amount of control work must always be done at larval habitats of the mosquitos. The degree of such anti-malarial work (ditching, fills, etc.,) will depend entirely upon whether the locality is to become a permanent settlement, or whether that locality, if untreated, would prove a serious menace to other localities.

Traps should at first be placed on all four sides of buildings to determine which side attracts the most mosquitos. Our data indicates that the *Anopheles* of Panama enter largely the traps on the lee sides of buildings. Probably this holds true elsewhere, but this fact should be determined at each new locality. Doors should be on the windward side of buildings, and they should be opened and closed as little as possible during dusk, the period of maximum *Anopheles* activity.

Houses should be well screened with 18-mesh wire screen, and all cracks, holes and openings in walls or floors must be stopped-up.

Mosquitos within buildings should be caught and killed daily. The best method is to use a killing tube such as described in these Annals, p. 16, vol. VI. A satisfactory scheme is to darken all windows but one, and to catch the *Anopheles* which go to the undarkened window. The time for such collections is at early dawn.

Ancon, C. Z., June 10, 1915.

THE CITRUS MITE NAMED AND DESCRIBED FOR THE FIRST TIME.

By E. A. McGregor,
Scientific Assistant, Bureau of Entomology,
U. S. Dept. of Agriculture, Washington, D. C.

The discovery which forms the text of this paper was the outcome of a study of types in the red spider collection of the Bureau of Entomology. Out of respect for previous workers in the acarid group the author wishes to state here that the anatomical studies, on which the present paper is based, were conducted with the aid of an oil-immersion lens and a camera lucida attachment. It has developed, through the studies of Mr. H. E. Ewing and the present writer, that the microscopic structures which constitute the taxonomic characters in the red spider group must be examined more critically than has been the practice with earlier workers if satisfactory specific demarcation is to be secured.

In 1885 Riley published* the original description of a mite under the name *Penthalodes mytilaspidis*, stating that "it possesses three claws, and that it is certainly predatory upon scale insects" on citrus trees. In 1900 Banks† re-named the species *Tetranychus mytilaspidis* stating that "This species is a true *Tetranychus* and not a *Penthalodes* * * * On careful observation I cannot discern any division to the lower (tarsal) claw in the many specimens examined (including Riley's types). It * * * probably feeds, like the other species of the genus, on plant juices." In his figure Banks shows only two divisions to the tarsal claw.

The writer's studies of Banks' red spider types included the slide which he says is probably the original type slide of Riley's *Penthalodes mytilaspidis*. In connection with this study the author went carefully through all of Hubbard's and Riley's acarid material in the National Museum and in the Bureau collection in an effort to locate material antedating that of the slide which Banks considers to be the valid type of *Penthalodes mytilaspidis*. Nothing was found that cast a shadow of a doubt on the validity of the Hubbard slide, and we may safely accept the material as representing the type specimens of the above species.

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*Hubbard, Orange Insects, p. 216.

†"The Red Spiders of the United States, Div. of Ent., Tech. Ser. No. 8, p. 71.

A study of the structure of specimens on Riley's type slide (see plate XIII) confirms his diagnosis of their identity. Riley states it "is one of the 'harvest-mites' belonging to the section Eupodidæ and comes nearer *Penthalodes* Murray than to any other defined genus, having 6-jointed legs (see plate XIII, fig. 2), of about equal length, * * * 'head' distinctly separated, narrow, elongate, conical. Mandibles scissor-like, projecting. Palpi * * * 4-jointed (fig. 1) * * *. Cephalothorax * * * merging posteriorly into the abdomen, so as to have no distinct division * * *. Surrounded by rather long and stout bristles * * *. Legs about equal in length * * *. Claws 3, much curved at tip * * *. (See plate XIII, figs. 3 and 4).

Considering the limitations of the microscopic equipment in use by workers of Riley's time, the above description tallies very well with the structures as shown in plate XIII. Some of the finer details do not conform to the original description, which is quite excusable. For example, Riley overlooked certain characters of the palpi (see plate 1, fig. XIII), and the plumose appendages of the tarsus (see plate XIV, figs. 3 and 4), which are invisible with magnifications weaker than the oil-immersion lens.

Finally, the notes on field observations, published at the time of the original description, prove that *P. mytilaspidis* is quite distinct from the citrus mite. Hubbard stated that "the eggs are sherry-brown in color, quite large and globular, and are usually deposited singly upon the leaf among scales, or strung like amber beads upon strands of spiders web * * *." Regarding the citrus mite, it has long been known that the egg is bright red in color, and is not globular, but lenticular with a slender stalk projecting from the center of the top side. Hubbard further states that "This mite is also very rapid in its movement." In this respect it agrees perfectly with the travel of predaceous mites—which Riley and Hubbard claimed the species to be. On the other hand it is entirely at variance with the rule in the group for red spiders to be very rapid of movement, and the citrus mite is no exception.

Banks concluded that the citrus mite is identical with Riley's *Penthalodes mytilaspidis* which is clearly not the case.

As a result the citrus red spider has never been technically named or described. It therefore becomes necessary to name and describe it.

Tetranychus citri sp. nov.

ORIGINAL DESCRIPTION.

Distinctly velvety-red in color. In size larger and more obese than the majority of red spider species. Female: length, .305 mm., width, .230 mm. A single eye cornea on each side, twice as far behind the subfrontal bristle as the latter's distance from the frontal bristle. Dorsal bristles long, stout, arising from prominent tubercles (see Plate XIV, Fig. 3); subfrontal bristles barely 3 times as long as frontals (see Plate XIV, Fig. 2); bristles sparsely pilose. Legs paler than body color, bristles 26, arranged chiefly in four longitudinal rows (see Plate XIV, Fig. 8). Mandibular plate abruptly narrowed anteriorly, tip rounded with an almost imperceptible emargination. Palpus is provided (see Plate XIV, Fig. 9), with a comparatively short "thumb," bearing a terminal, slightly clavate "finger" whose base is less than half the width of tip of "thumb"; with two pseudo-fingers arising on either side of the upper distal corner, which are not greatly thicker than hairs; on upper side hardly midway to base with a small "finger" between which and base are two, short, stout hairs; near the lower center of the outer side of the "thumb" with a hair which reaches to the tip of the terminal "finger"; with the claw on the penultimate joint stout and reaching to the dorsal "finger"; a strong hair arising laterally from the center of the penultimate joint, another arising from the center of the dorsal face of this joint which equals the claw, and a short, weak hair with its origin on the inner base of claw; and with a very strongly tubercled spur arising distally from the top of the antepenultimate joint of the male (see Plate XIV, Fig. 7). The legs (see Plate XIV, Fig. 1), are relatively short; femur somewhat more than twice as long as wide, barely equalling tarsus; tibia a little longer than patella which is one-third again as long as trochanter. Tip of tarsus (see Plate XIV, Fig. 6), bears a claw which is rather straight for two-thirds its length and then bent sharply downward; at a point one-third the length of the claw from its base arise six slightly curved spurs whose tips surpass that of the main claw: the four usual capitate hairs arise two on either side of the base of the claw.

The male is considerably smaller than the female (length .216 mm., width .146 mm.), abruptly narrowed posteriorly. The legs appear longer in proportion to the body than in the case of female, and are salmon pink. The distribution of dorsal bristles (see Plate XIV, Fig. 8), is similar to that of female. Penis (see Plate XIV, Fig. 4), comparatively short; inner lobe long, rod-like, about 3 times as long as the shaft; shaft very stout and short, becoming abruptly smaller distally, and bent upward at an angle of 120 degrees to form the attentuate hook which is considerably longer than the shaft; basilar lobe present on upper side of shaft as a strong, conical projection; hook possessing no barb, being spine-like terminally.

The egg is bright red in color, sphero-lenticular, with a vertical stalk arising from the center of the top side which in length is about twice the diameter of the egg. Several guy fibrils radiate downward from the apex of the stalk to the leaf surface, thus giving additional attachment to the egg.

Type No. 20362, U. S. Nat. Mus.

The type material is from Orlando, Florida, March 7, 1916, from the leaves of lemon, collected by W. W. Yothers. The species is in the group containing *T. yothersi* McG. and a species soon to be described by the author, of the United States, and *Paratetranychus* (*Tetranychus*) *pilosus* Zacher (Can. & Fanz.) and *P. ununguis* Zacher (Jac.) of Europe.

NOTES

Mr. Yothers, who for years has been engaged in studying the entomology of citrus trees in Florida, writes as follows. "*Tetranychus mytilaspidis* is most abundant during the spring of the year. I would say its period of maximum occurrence is from the first or middle of December until the first of May. It occurs most abundantly on lemon and sour orange, and it appears in great numbers in nurseries where these species are grown for stock upon which to bud. I have seen it so abundant on sour stock as to cause the stems of the young trees to turn blue for a distance of two feet from the top downward. Its next most favorable food plant is the grapefruit. I rather doubt that it is of any great economic importance on this fruit. It also can be found on sweet orange, but it is of little or no importance on this fruit."

The citrus mite was introduced into California from Florida on nursery stock about 1890. While the species does not seem to be as injurious in Florida as the so-called 6-spotted mite, its work in California, as early as 1900, was such as to demand urgent action. It is an interesting problem to account for the fact that the citrus red spider is severest as a pest of sweet orange in California, whereas in Florida it all but forsakes the sweet orange and is only severe upon lemon, sour orange, and grapefruit.

The citrus red spider on orange in California produces a silvering, dwarfing, and dropping of the fruit, and also causes discoloration and dropping of the foliage. It gives trouble in packing houses since it readily attacks the picked fruit. This species is doubtless the most injurious of those found on citrus trees on the Pacific Coast.

EXPLANATION OF PLATES.

Plate XIII.

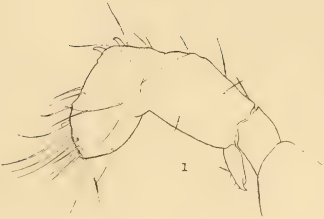
Penthalodes mytilaspidis Riley.

Fig. 1. A nearly lateral view of palpus.
Fig. 2. Dorsal view of adult showing distribution of bristles, and right foreleg.
Fig. 3. Tip of tarsus, showing appendages (lateral view).
Fig. 4. Same (ventral view).

Plate XIV.

Tetranychus citri sp. nov.

Fig. 1. Right foreleg (dorsal).
Fig. 2. Frontal and subfrontal bristles.
Fig. 3. Attachment of dorsal bristles to tubercle.
Fig. 4. Penis.
Fig. 5. Profile view of female (only proximal portion of legs shown). X 166.
Fig. 6. Tip of tarsus with appendages.
Fig. 7. Section of palpus of male showing tubercled spur.
Fig. 8. Dorsal outline of male showing distribution of dorsal bristles. X 436.
Fig. 9. Left palpus of female (outer view) showing "thumb," claw, and other appendages.



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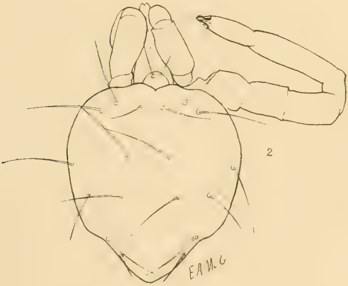

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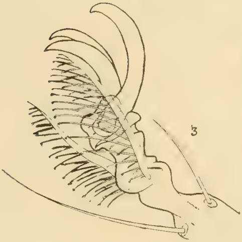

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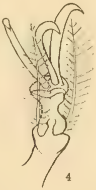

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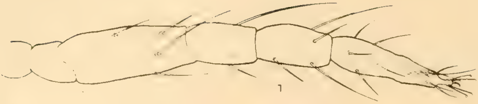
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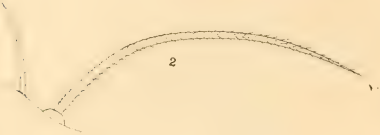
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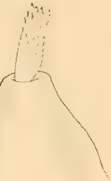
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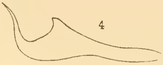
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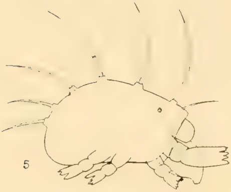
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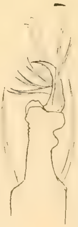
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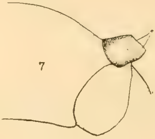
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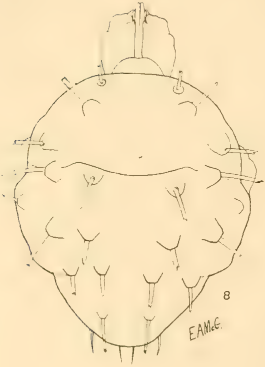
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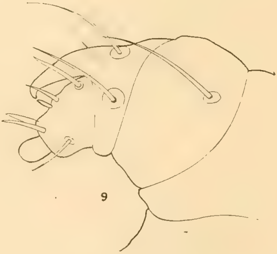
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E. A. McGregor

NEW MISCELLANEOUS CHALCIDOID HYMENOPTERA WITH NOTES ON DESCRIBED SPECIES.

By A. A. Girault.

Ablerus peruviana new species.

Female: Length, about 1.10 mm.

Ovipositor half the length of the abdomen, white tipped. Dark metallic green, the following parts silvery white: Vertex, scape except bulb and middle, apical half of the pedicel, funicles 2 and 4, trochanters, knees, tips of tibiæ and middle three joints of the tarsi. Venation dusky, base of marginal vein and the stigmal vein pale. Fore wings with a distinct, oblique (caudo-distad), sooty cross-stripe from the distal two-thirds of the marginal vein and the side of the stigmal. Marginal fringes of the fore wing short, the longest not an eighth of the greatest wing width. Pedicel somewhat longer than wide, barely shorter than funicle 1 which is over twice longer than wide; funicle 2 thrice longer than wide and longest, 4 slightly shorter than 2, 3 slightly longer than wide. Club longer than the two preceding joints combined. Mandibles tridentate.

The male is about the same but the antennæ are wholly black; funicle 3 wider than long, the others subequal and nearly thrice longer than wide; club unjointed, longer than the funicle joints (any one).

From a pair on a slide in the U. S. N. M., from Coscomba, Peru (C. H. T. Townsend).

Types: Catalogue No. 19929, U. S. N. M., the above specimens.

Pentastichus xanthopus Ashmead.

The antennæ are as in *Tetrastichus*, the two ring-joints rather large and distinct but the club is only 2-jointed and with a short terminal nipple. Sculpture usual. Fore wings as in *Tetrastichus*, the marginal fringes barely longer than usual (*i. e.*, not extremely short). Venation yellow. Thorax as in *Tetrastichus*. Dark metallic green. Legs and antennæ golden yellow. Propodeum short, with at least a median carina. Funicle joints subequal, but 1 a little longer than wide, 2 and 3 each a little wider than long. The genus is valid. Original description otherwise correct.

From 1 ♂, 2 ♀ types in U. S. N. M. (♀ wings, 3 antennæ and head on a slide).

Ablerus perspeciosus new species.

Female: Length, 0.65 mm., excluding the ovipositor which is white at tip and extruded for a length equal to a fourth of the abdomen.

Like *capensis* Howard but may be distinguished from that species in that the fore wings bear a third fuscous patch which is proximad from the base of the marginal vein and which is long-cuneate and densely ciliate; it is oblique and extends nearly to the middle of the second infuscation, a broad cross-stripe which differs in shape from the one in *capensis*, being straight with parallel margins, narrowing to a sort of neck cephalad, the neck against the base of stigmal vein and bearing a dense patch of black bristles; the distal cross-stripe is also different, shaped like an inverted ? but without the dot (it is like a spread bat in *capensis*). Moreover, the legs are concolorous except the knees, tarsi (except joint 5) and distal half of all tibiæ. Head white with a cross-stripe of brown-black across below the eyes. Scape (except at base and a broad middle portion), distal half of the pedicel, funicles 2 and 4, silvery. Funicle 3 a little longer than wide, 1 and 4 subequal, twice longer than wide (4 stouter and not quite that length), 2 slightly shorter than 1. Pedicel barely shorter than funicle 1. Parapsides white at distal apex. Cephalic tibiæ all dusky save at tip.

Described from four females on a slide labelled "from *Diaspis pentagona*. Nishigahara, Japan, July 16, 1909. S. I. Kuwana, No. 33."

Types: Catalogue No. 19930, U. S. N. M., the above specimens.

Habrocytus obscuripes Ashmead.

Resembles *Aetroxys callidii* Ashmead but that species has pubescence as in *Catolaccus* and the postmarginal vein is distinctly shorter than the marginal (mandibles not examined). Colored like *Rhopalicus coloradensis* Ashmead but more slender, the parapsidal furrows slightly longer and slightly more complete in that species and funicle 1 there is about twice longer than wide, here only about a half longer than wide; also in the larger species, there is an obtuse cross-carina on the distal scutellum. The mandibles are alike in both, 3- and 4-dentate. Somewhat like *Cecidostiba dendroctoni* Ashmead but the latter has both mandibles tridentate, the incomplete parapsidal furrows are more meso-transverse and the antennæ more slender, the funicle joints longer, 1 over thrice longer than wide, 2 and 3 each nearly as long as 1.

Many specimens reared in connection with the strawberry weevil, St. Paul, Minnesota (S. Marcovitch). The scutellum is simple.

Cirrospilopsis fuscipennis new species.

Female: Length, 1.00 mm.

Orange yellow, the abdomen dusky but the incisions of the segments showing through as dull yellow; meson of propodeum and last two pairs of tibiæ, blackish. Fore wings hyaline but with a conspicuous smoky cross-stripe from the marginal vein, the apical margin of which slopes distad from the apex of the stigmal vein for a length about equal to that vein, then slopes back, thus a cone; its proximal margin is nearly straight and a little distad of the origin of the marginal vein. Venation dusky yellow, the marginal vein nearly as long as the submarginal, over thrice the length of the rather long stigmal, the latter a third longer than the postmarginal. Marginal cilia of the fore wing distinctly longer than usual, about somewhat longer than a fourth the greatest wing width. Marginal vein with long bristles. Mandibles 5-dentate. Pedicel a half longer than wide at apex, longer than either funicle joint of which 2 is subglobular, 1 somewhat longer than wide. Terminal nipple of club small, distinct. Caudal wings where broadest with about eight lines of discal cilia. Head and thorax finely reticulated. Propodeum with a median carina and no others. Club rather large. Abdomen longer than the thorax. Fourth joint of the tarsi black.

Described from one female captured September 11, 1915, by sweeping meadows at Glenndale, Prince George County, Maryland.

Type: Catalogue No. 19931, U. S. N. M., the above specimen on a tag, the head, a hind leg and the fore wing on a slide.

Uscanopsis new genus.

Female: In my table to the *Ophioneurini* runs to *Uscanoidea* Girault but differs from that genus in bearing two ring-joints in the antennæ and both the marginal and stigmal veins are distinctly longer, the stigmal vein with a distinct, rather slender neck, the oblique line of cilia from the stigmal vein is present (not isolated but limiting the discal ciliation proximad). Marginal vein somewhat over half the length of the submarginal. Club conic-ovate, with rather long, scraggly hairs, its second joint much the longest, joint 1 much wider than long. Caudal wings short and broad, with three lines of discal cilia, the fainter one caudad, the others paired. Male the same but the club shorter. Discal ciliation of fore wing normal, that is, not in regular lines, not so dense as in *Tumidifemur*. Tarsal joints short. Cephalic tibial spur minute, straight, the caudal one elongate, three-fourths the length of the tarsus. Club articulation not very distinct. Otherwise as in the named genus.

Uscanopsis carlylei new species. Genotype.

Female: Length, 0.60 mm.

Black, the head and thorax (except a cuneate marking from cephalic margin of scutum to distal fourth and the disk of the parapsides) orange yellow, the fore wings infuscated lightly from the bend of the submarginal vein distad indeterminately a little beyond the venation, the latter dusky. Legs dusky except articulations, tips of tibiæ (more broadly in the cephalic ones) and the tarsi. Club two and a third times longer than wide at base, terminating in a pair of the rather long setæ. Marginal cilia of the fore wing short but not extremely so, distinct, the fore wing shaped about as in *Trichogramma*. Mandibles equally tridentate. Body as in *Pterygogramma*. Middle tibial spur slender, slightly less than half the tarsal length, the caudal one rather stout. Male the same, the abdomen more blunt at apex.

Described one male, five females on a slide labelled "53-42. Reared from egg-mass of *Membracis tectigera*. Port of Spain, British West Indies, March, 1915, F. W. Urich."

Types: Catalogue No. 19932, U. S. N. M., the above specimens on a slide. A second slide with fragments retained as paratypes.

Oligosita oophagus new species.

Female: Length, 0.70 mm.

Bright golden yellow, the eyes darker, last tarsal joint black, the metapleurem with a longer than wide, oblique black spot. Differs from *americana* in that the funicle joint is distinctly longer than wide, the fore wings broader and with more discal ciliation, the pedicel more slender and so on. From *comosipennis* in that the fore wings are not so broad, the color much lighter, the pedicel a little more slender. The male differs in bearing a broad black band across the abdomen just distad of the middle. Distal edge of fore wing embrowned.

Described from six males, twelve females reared from an egg-mass of a leaf-hopper embedded in a leaf of sugar cane, Diego Martin, British West Indies, January, 1914 (F. W. Urich).

Types: Catalogue No. 19933, U. S. N. M., two males, four females on a slide. Six females on another slide, the same number, as paratypes.

Oligosita comosipennis in Girault, 1914 (Canadian Entomologist, p. 328) is no doubt this new species.

Achrysocharis partifuscipennis new species.

Female: Length, 0.55 mm.

Dark metallic green, the abdomen black, the legs white except caudal coxæ and bases of the other coxæ; scape pale along about its proximal half. Fore wings hyaline, with a distinct yet faint cross-stripe from the whole of the marginal and stigmal veins, the venation dusky yellowish, the postmarginal vein shorter than the stigmal. Mandibles tridentate. Caudal wings with about five lines of discal cilia where broadest. Head and thorax uniformly scaly, the propodeum smoother, with no median nor lateral carinæ. Parapsidal furrows complete.

Marginal fringes of the fore wing of moderate length, the longest about a third of the greatest wing width, the discal cilia of the fore wing limited proximo-caudad by a regular line of cilia. Pedicel a half longer than its greatest width (before apex), subequal in length and width to funicle 1; rest of flagellum slenderer, filiform-acuminate. Funicle 2 twice longer than wide, longer than club 1, subequal to club 2, club 3 longest of the flagellum, acuminate, three and a half times longer than its greatest width (not far from base) and terminating in a long, distinct spine which is about half of its length. Fore wings obtusely rounded at apex, moderate to narrow.

Differs from *Achrysocharella americana* (types compared) in having the more slender, tapering flagellum, the darker scape, smaller mandibular teeth, infuscated wings and so forth.

Described from one female captured by sweeping meadows at (Hillmead) Glenndale, Prince George County, Maryland, September 11, 1915.

Type: Catalogue No. 19934, U. S. N. M., the above specimen on a slide.

Epitetrastichus marylandensis new species.

Female: Length, 1.65 mm.

Orange yellow, the abdomen and legs yellowish brown, the following black portions: Face of pronotum centrally, flagellum and five pairs of cross-stripes on the abdomen, the second stripe of each pair abbreviated except the distal pair which is a little distance before apex. Second stripe of first pair much abbreviated, merely a transverse dash across meson, that of the fourth pair longer than that of 2 and 3 and projected a little proximad at the meson; that of pair 2 joined along the meson to the first stripe of pair 3. Ovipositor valves black. First pair of cross-stripes near base. Meson and cephalic margin of propodeum dark brown, the propodeum very short at the meson, with a carina there but no others. A line of short, black setæ across caudal margin of pronotum and lateral margin of the scutum. Apex (cephalad) of axillæ a little dusky, otherwise about as in *cuneiformis* (in death, the dorsal abdomen of the latter appears black except at base and just before apex; its propodeum is longer at the meson but not long). Distal half of scape dusky. Terminal nipple of club minute, smaller than with *cuneiformis.* Mandibles tridentate.

Described from one female captured by sweeping meadows at Glenndale, Prince George County, Maryland, September 11, 1915.

Type: Catalogue No. 19935, U. S. N. M., the above specimen on a tag, the head on a slide.

Aprostocetus whitmani new species.

Female: Length, 2.00 mm.

Very dark metallic purple, the wings hyaline; scape, a little less than the proximal fourth of the abdomen (except along the latero-dorsal margin rather broadly) and the legs except all coxæ and first two pairs of femora (except at tip). Venation pale. Scape stout, its short bulb purple; pedicel a little longer than wide at apex, a little longer than club 3. Ring-joint large. Funicles 2 and 3 subequal, each twice longer than wide, stout, 1 somewhat shorter, longer than the pedicel. Club 3 with a distinct terminal nipple; club 1 a little shorter than funicle 1, longest of the club by a little. Mandibles tridentate. Sculpture usual; a line of rather obscure punctures along the lateral margin of the scutum. Propodeum and abdomen densely finely scaly, the former longer laterad, with a distinct median carina and a very delicate, short, curved lateral one from caudad (half or less complete). Cephalic femora more broadly white at tip. Pedicel whitish, purple above at base. No postmarginal vein, the stigmal moderately long. Abdomen conic-ovate, pointed, somewhat longer than the rest of the body. Fore wings broad.

The male is the same but the abdomen is oval, flat and short, the scape compressed and dilated (uniformly, nearly, for its entire length), purple above and below, the funicle is white, also the club except the distal joint. Also, the cephalic femur is purple only dorsad centrally and the middle one only centrally. The funicle is 4-jointed, the club 3-jointed and as in the female except the middle joint is longest. Funicles 1–2 subequal, a half longer than wide, 2–3 subequal, each nearly twice longer than wide. Club 2 subequal to funicle 2.

Described from one male, eight females, reared from the eggs of *Physonota unipunctata*, St. Paul, Minnesota (S. Marcovitch).

Types: Catalogue No. 19936, U. S. N. M., the above specimens on three tags plus a slide bearing a male and female head.

Rhopalicus americanus new species.

Female: Length, 3.00 mm.

Bright metallic green, the legs, scape and pedicel reddish yellow tinged centrally with brownish, the venation yellow, the fore wings with a large fuscous blotch from the whole of the marginal vein, this blotch oblique, rectangular (longer than wide, its sides parallel, its apex reaching slightly beyond the middle of the wing and fainter). Head and thorax very finely punctate, the clypeus bidentate at apex. Antennæ inserted slightly below the middle of the face, 13-jointed with two ring-joints (the second the larger), the club short, ovate; funicle 1 a half longer than wide, subequal to the pedicel, 2 a little shorter than it, 3 and 4 subequal, each slightly longer than wide, the rest quadrate.

Marginal vein subequal to the elongate stigmal, somewhat shorter than the postmarginal. Cephalic femora but moderately swollen. Parapsidal furrows just indicated cephalad. Propodeum of moderate length, with a median carina and no others except short rugæ from its cephalic margin; no spiracular sulcus. Cephalic coxa metallic at base laterad, hind coxæ all metallic. Propodeum without a neck, its caudal margin rimmed. Abdomen produced beneath, conic-ovate. Mandibles tridentate.

Described from one female in the U. S. N. M., "Agricultural College, Michigan, 7–26–1890."

Type: Catalogue No. 19937, U. S. N. M., the above female plus a slide bearing a head, a hind leg and a fore wing.

Coccophagus cinguliventris Girault.

Male: In the male the yellow band on the abdomen is very short, subobscure; the head and thorax more brownish. One male, two females reared from *Lecanium corni* at Madison, Wisconsin, June 22, 1915. (F. A. Fenton.)

ARTHOLYTIS APATELÆ and **A. PIMPLÆ** Ashmead are synonyms. The median carina of the propodeum is delicate. There is a round fovea at cephalic margin of propodeum at mesal base of the delicate lateral carina. The propodeal spircale is round, small. The second ring-joint is larger than the first; funicle joints widening distad, 6 largest, all wider than long and much shorter than the pedicel.

Gonatocerus triguttatus new species.

Female: Length, 0.85 mm. The ovipositor slightly extruded.

Dull honey yellow, the wings hyaline, the following parts black: Ocellar area, dorsal and ventral edges of the scape, flagellum, marginal and stigmal veins, abdomen, three round spots on thorax, the mesal one between the axillæ and ends of the parapsidal furrows (not on the scutum), the lateral ones on the axillæ cephalad and laterad. Tibiæ darker than the rest of the legs, but not much more so. Scape considerably but not greatly convexly dilated ventrad. Pedicel short, only slightly longer than wide, shorter than funicle 1 which is subequal to 2 and longest (or slightly shorter than 2 which is thrice longer than wide); funicle 3 subequal to 1, the others shortening in succession, 8 slightly longer than wide. Fore wings of moderate width, their marginal cilia moderately short, about an eighth of the greatest wing width. Head and thorax glabrous. Scutum with an embrowned triangular scalelike area on each side of the meson cephalad. Propodeum with a pair of delicate median carinæ, widely separated and a distinct, curved "lateral carina" which originates caudo-laterad of the minute spiracle. Scutellum separated from the scutum by a transverse sclerite which runs caudad of the axillæ and is longer than the postscutellum. Caudal wings narrow.

The male the same but the three spots on middle thorax are more or less connected transversely (they are in a line in both sexes), the scutellum is all black except its margin all around, the scutum is entirely black and on each parapside there is an exclamation-point-shaped marking at cephalic margin, this transverse and with the thickened end laterad (sometimes present in the female). The abdomen is yellow, striped with black. Scape very short, the pedicel extremely so; funicle joints lengthening distad, the longest about thrice longer than wide; club joint distinctly longer than funicle 1.

Described from one male, seven females reared from an egg-mass of a leaf hopper on orange, Caroni, British West Indies, February, 1913 (F. W. Urich).

Types: Catalogue No. 19938, U. S. N. M., the above specimens on tags.

Habrocytus quinquefasciatus new species.

Female: Length, 3.25 mm.

Dark metallic green, the propodeum bright green, the wings hyaline, the venation, abdomen, pedicel and basal half of funicle 1, reddish yellow; legs and scape light yellow. Abdomen with five distinct metallic blackish cross-stripes, the first thinnest, at apex of segment 2, 5 at apex, 4 as long as 5 and apparently across the middle of segment 6, 3 mostly on the basal four-fifths of segment 5. Tip of ovipositor valves black. Mandibles 3- and 4-dentate. Head and thorax finely punctate, the clypeus striate, incised medially. Segment 2 of abdomen occupying nearly a third of the surface, smooth, rest of abdomen finely scaly along cephalic margin of the segments; a little scaliness on segment 2. Scutellum without an obtuse cross-carina. Propodeum with a distinct median carina, no lateral one but there is an obscure cross-carina from the median one cephalad to the spiracle and short longitudinal carinæ from the cephalic margin to this and dividing foveæ (extending for a little over half way to the spiracle from the meson). Also on the short neck there are short carinæ. Spiracle of propodeum longer than wide; of moderate size. Antennæ inserted below the middle of the face yet slightly above the ventral ends of the eyes, 13-jointed with two ring-joints; funicle 1 elongate, widening distad, over twice longer than wide at apex, distinctly longer than the rather long pedicel which is twice longer than wide, slender, 6 wider than long, 4 quadrate; second ring-joint twice the length of the first. A marginal spot on the abdomen a little distad of middle of segment 2. Parapsidal furrows about two-thirds complete, not deep. Marginal vein slightly longer than the elongate stigmal, the latter a little shorter than the postmarginal.

The male is the same but the abdomen has a broad white stripe across it some little distance out from base (longer than the basal black and extending a little beyond segment 2, the latter longer than in the female) followed by a cross-stripe of black which is narrow and divided along the meson, then by a second, very narrow white stripe, thence black. The obscure cross-carina on propodeum here absent. Antennæ with the pedicel slightly longer than wide.

Described from a single pair labelled "3816°1, March 6, 1886." Eastern United States.

Types: Catalogue No. 19939, U. S. N. M., the pair on a tag plus a slide bearing a female head, fore wing and hind tibiæ and a male antenna.

Anastatus aureicorpus new species.

Female: Length, 4.00 mm., excluding the ovipositor, which is extruded for a length equal to a half that of the abdomen.

Reddish brown or orange, the club black, the scutum between the lateral ridges and caudad of the cephalic triangular piece, dark metallic purple; ovipositor valves soiled yellowish (but most of apical part missing). Fore wings with a reddish brown stripe across them from the bend of the submarginal vein to apex of stigmal, this stripe fading near caudal margin. Funicle 1 quadrate, 2 subequal to the pedicel, longest, thrice longer than wide, 3 and 4 subequal, each slightly shorter than 2; 8 slightly longer than wide, larger than 2. Club short, obliquely truncate from base of joint 3. Ocelli in small metallic spots. Caudal coxæ and funicles 1–3 darker. Postmarginal vein short, slightly longer than the stigmal. Raised triangular piece of the scutum and the somewhat separated axillæ more coarsely scaly than the rest of the body, the scutellum with scattered, short black setæ. Face above the antennæ with grayish, stiffish pubescence (longer along the eyes). Segments of abdomen with straight caudal margins. Abdomen as long as the thorax.

Described from one female on a tag labelled "Austin, Texas, Carl Hartman" and reared from what appears to be a syrphid puparium.

Type: Catalogue No. 19940, U. S. N. M., the above specimen on a tag.

Abbella subflava Girault.

Five females reared as hyperparasites of *Polynema eutettexi*, from beet leaf-stems, August 28, 1915, Spreckels, California. The cheeks and sides of the thorax were dusky; otherwise like the types and probably a variety.

Crataepus fletcheri Ashmead.

As described. Cephalic tibiæ with a strong, black, bifurcate tibial spur. Antennæ short; scape like a rather long pedicel, the latter somewhat shorter than the scape, slightly longer than wide at apex; funicle joints all hemispherical and wider than long, 1 largest, 2 and 3 subequal; club 3-jointed, not as long as the funicle, its first joint half, its last joint small, distinct, with three minute, acute nipples at apex. Three ring-joints of which the middle is largest, distinct. Postmarginal vein absent, the stigmal long. Scutum with a median groove, flat, the scutellum with four. Pronotum flat, *large*. Antennæ 11-jointed, the funicle and club each 3-jointed.

From the type in the U. S. N. M. (a fore leg and antenna on a slide).

Ceranisus flavopictus Ashmead.

The types are unrecognizably mutilated but the female scape (the only part of the antennae present) shows no dilation and the marginal fringes of the fore wing are short and usual. The color appears to be wholly black. The species is hopeless.

Sympiesomorphelleus whitmani new species.

Female: Length, 1.85 mm.

Reddish brown, the wings hyaline, the abdomen and legs (also scape) yellowish brown; the following black parts: Center of occiput, ocellar area, flagellum and apex of the scape, pronotum (except the neck), cephalic fourth of scutum (except along the meson narrowly), axillæ, scutellum laterad of the groove, propodeum lightly distad (its well-defined neck) and along the meson and the margins of the abdomen from base to about middle (but broken in two places). Also the post-scutellum and a narrow line from the spiracle on the propodeum. Median carina of the propodeum forming an X whose distal arms are very long, the carinæ joining not far distad of their origin; no lateral carina. One spur of hind tibiæ small. Mandibles 7-dentate. Pedicel somewhat longer than wide, shorter than any funicle joint; funicles 1–3 subequal, each about thrice longer than wide, 4 slightly shorter, club joints about equal in length, 1 about twice longer than wide, 2 terminating in an acute, spinelike point. Flagellum filiform. Thorax scaly reticulated. Grooves of scutellum practically joined around the apex. Postmarginal vein much longer than the stigmal, the marginal long.

Described from a female in the U. S. N. M., labelled "174. Gifu, Japan, Y. Nawa Collection."

Type: Catalogue No. 19941, U. S. N. M., the above specimen on a tag, the head and hind legs on a slide.

Cheiloneurus albicornis Howard.

Differs from the original description of *albicornis* Howard as follows: The middle tibiæ are purple except at tip and a silvery area just before base; the caudal femur interiorly has a middle silvery streak along its distal half or more (in some specimens); in some specimens the middle tibia is silvery along its distal half. The scape is distinctly dilated but not greatly.

The male is wholly blue, the wings hyaline, the legs except the last tarsal joints and most of the caudal tibiæ and the antennæ except scape and pedicel, pale yellow. Club solid, the flagellum clothed with whorls of long hairs. Pedicel very short. In the type female, the middle tibia is dark just below the knee.

One male, seven females reared from *Pulvinaria* spp. on Poison Ivy, Madison, Wisconsin and from *Physokermes piceæ* on *Picea abies*. The mandibles in all specimens were as in *Cristatithorax*.

In the male, funicles 1 and 6 are longest, nearly thrice longer than wide, shorter than the club; funicles 2 and 3 subequal, shortest, the joints widest a little out from the base. Club five times longer than wide, or more.

Ooctonus quadricarinatus new species.

Male: Length, 1.30 mm.

Propodeum with a pair of median carinæ which diverge widely to middle, then converge to apex, forming a large diamond; its caudal and cephalic margins carinated; and a strong lateral carina which from cephalad runs meso-caudad for over half way, joining (or nearly) the lateral angulation of the diamond of the median carinæ, thence for a short distance latero-caudad to apex; this shorter arm forms therefore a rather small, distinct diamond-shaped areola. Lateral margin also strongly carinated and between this and the minute spiracle runs a long, oblique, smooth groove. Propodeum and postscutellum glabrous; rest of thorax strongly scaly. Scutellum divided by a semi-circular cross-suture whose apex is proximad of the middle, the convexity facing cephalad. Lateral margin of postscutellum carinated. Head finely scaly. Abdominal petiole long, somewhat longer than the caudal coxæ. Black, the wings hyaline, their venation black; tarsi, knees, tips of tibiæ rather broadly and scape and pedicel, more or less reddish brown. Characterized by the very broad fore wings which are subtruncate at apex and bear about 38 lines of very fine discal cilia where widest, the longest marginal cilia not a tenth of the greatest wing width. Caudal wings with 4–5 lines of discal cilia. Pedicel a little longer than wide; funicle joints six or more times longer than wide, the club shorter but somewhat longer than funicle 1. Proximal tarsal joint much the longest. Venation elongate.

Described from three males reared in connection with bark beetles (from limbs of pine infested with *Pityogenes hopkinsi*) August 16, 1915, New York. The locality is Syracuse.

Types: Catalogue No. 19942, U. S. N. M., the above specimens on a slide.

Anicetus chinensis new species.

Female: Length, 2.00 mm. Ovipositor extruded a short distance.

Differs from the genotype in being larger, in being deep orange in color with the disk of the abdomen and a broad line down propodeum between the spiracle and meson, deep metallic purple. The antennæ are purple suffused with yellowish. Fore wings yellow from a little before the bend of the submarginal vein distad to near apex, the distal margin of this yellow flatly convexed and browner like a ring (as in the Australian *felix*). Mandibles with three distinct, equal, acute teeth. Frons subprominent, the great inflexion of the face with an acute, convex, dorsal margin. Frons moderately narrow, a little over thrice the diameter of the cephalic ocellus. Cheeks as long as the eyes. Axillæ with a carina between them. Pedicel greatly concaved and winged at apex. Differs further from *ceylonensis* in the larger pedicel. Funicle with a backbone, the joints given off as so many vertebræ, the first much narrower than the last which is as wide as the club. Marginal vein thrice longer than wide, the stigmal a little shorter than it, a fourth longer than the postmarginal. Frons with several rows of shallow punctures (caudo-cephalad). Pronotum transverse, the middle of its cephalic face purple. Head and thorax very finely sculptured, giving a velvety sheen. Margin of abdomen at base purple. Thorax with scattered, obscure setigerous punctures. External valves of ovipositor purplish. Tibiæ setose. Hairless line of fore wing with many lines of cilia proximad of it. Caudal wings broad (about 25 lines of rather fine discal cilia). There is a dusky line across the face as in *felix* and the genotype.

Described from one female on a tag from China and reared from a Lecanium (Compere).

Type: Catalogue No. 19943, U. S. N. M., the above specimen plus a slide bearing the head and a pair of wings.

The genotype has the club obliquely truncate from the base of the third joint and the scape is edged with black ventrad; the marginal vein is about twice longer than wide, somewhat shorter than the stigmal. The mandibles were missing in the single specimen. The caudal wings are hyaline excepting for a long-ovate, fuscous spot just under the apex of the venation; they bear about 22 lines of discal cilia where broadest.

The genus *Habrolepopterygis* Girault is a synonym of *Anicetus*.

Sympiesomorphelleus bicoloriceps new species.

Female: Length, 2.25 mm.

Lemon yellow, the wings hyaline, the body marked with black as follows: Upper half or more of head except a flat triangular area on vertex against the eye, a median stripe up the occiput (upper part) to vertex, cheek right under apex of the eye and a spot on face against the eye; a rather broad, oblique stripe down propodeum through the spiracle (forming a V but the letter not quite joined at apex); ovipositor valves, a spot on each side of meson of abdomen at apex and a long-obovate stripe from base down meson of the abdomen to distal sixth (widest at about the middle of the abdomen). Flagellum and distal third of hind tibiæ fuscous. Caudal spurs long, stout. Pedicel barely longer than wide; funicle 1 twice longer than wide, longest, 4 a half longer than wide, somewhat longer than club 1; terminal nipple of club subobsolete, its joint longer than the pedicel. Postmarginal vein twice the length of the stigmal, about a half the length of the marginal. Pronotum, scutum, parapsides and dorsal abdomen (except distal edges of segments) distad of segment 2 rather coarsely reticulated, the scutellum glabrous and so the rest of the thorax. Propodeum with a pair of delicate median carina which diverge at *base* (cephalad) and no true lateral carina, the spiracles reniform. Groove of scutellum just mesad of the two bristles on that side of the scutellum. Segments 2 of abdomen occupying a fourth of the surface. Head and cephalic thorax with scattered, rather long hairs. Antennæ inserted just above the ventral ends of the eyes.

Described from two females on tags in the U. S. N. M., labelled "From *Tinea* on *Solanum*, August 11, 1886, C. V. Riley."

Types: Catalogue No. 19944, U. S. N. M., the above specimens and a slide bearing a fore wing, hind tibiæ and antennæ.

Miotropis platynotæ Howard.

This is a species of *Sympiesomorphelleus.* Propodeum with a delicate paired median carina and a curved lateral one. Scutellum distinctly scaly but not as coarsely as the scutum. Brown margins of the abdomen indefinite, the dusky spot of the disk also, often absent. Mandibles 8-dentate. Funicle 1 twice longer than wide, 4 a fourth shorter. Terminal spine of club distinct but not large. Pedicel shorter than funicle 4. From the female types (hind tibiæ and head mounted on a slide).

Stigmatotrastichus new gėnus of the Ceratoneurini.

Female: Head flattened or very thin, concaved, longer than wide, the antennæ inserted below the middle of the face yet above the ventral ends of the eyes, the vertex elevated. Pronotum large, conical, as long as the peltate scutum, the latter simple. Scutellum with four delicate grooves; abdomen with a distinct, quadrate petiole, flattened above, not so long as the thorax. Propodeum large, with a delicate median carina and apparently a weak lateral carina directly from the spiracle. Marginal vein long, as long as the submarginal and distinctly, conically thickened at base, the thickened part black and conical, a third of the length of the entire vein. Postmarginal vein distinct, short, not quite half the length of the stigmal which is about a fifth the length of the marginal. Marginal cilia of the fore wing a little longer than usual.

With the habitus of a Pirenine, Tetracampine or *Spalangia*. Caudal tibial spur single, small. Proximal tarsal joint longest of the four. Sculpture very fine, usual for the group. Coxæ elongate. Antennæ 10-jointed with two ring-joints.

Stigmatotrastichus emersoni new species. Genotype.

Female: Length, about 0.90 mm. Very dark æneous black, the scape, the pedicel except above, coxæ, tarsi except the last joint, tips of tibiæ, proximal third of caudal tibiæ (and very much less of the other tibiæ) and the abdominal petiole, white. Fore wings embrowned (most deeply under the marginal vein) but clear under distal three-fourths of the submarginal vein and with a hyaline, subnaked cross-stripe (abbreviated caudad) from the apex of the postmarginal vein (crossing the stigmal). Pedicel elongate, over twice longer than wide, a little over half the length of the scape. Funicle 1 subequal to the pedicel, 2 much shorter, somewhat longer than wide, 3 subquadrate, as long as club 3 (the longest of the club) which ends in an acute, nipple-like point. Bulb of scape black. Ring-joints sub-equal, distinct.

Described from a female on a tag in the U. S. N. M., labelled "*Paraspalangia annulipes* Ashmead, female type. Type No. 12731, U. S. N. M. College Station, Texas, Banks, September."

Type: Catalogue No. 12731, U. S. N. M., the foredescribed female and a slide bearing an antenna, a fore wing and the caudal legs.

Paraspalangia Ashmead was proposed as a new genus in the Spalangiinæ but no species was ever described though one was named as above.

Parecrizotes new genus.

Female: In Ashmead's table to the Pireninæ runs to *Ecrizotes* Foerster but differs from that genus in having the marginal vein distinctly thickened at base, the thickening conical distad and occupying about half of the length of the vein which is somewhat less than twice the length of the well-developed, curved stigmal, the latter a little shorter than the postmarginal. Ovipositor valves extruded for a length about half that of the abdomen, the latter conical and a little longer than the rest of the thorax. Parapsidal furrows complete, deep, Scutellum simple. Propodeum very short at the meson, lengthening laterad, practically noncarinate. Pronotum subtransverse-quadrate. Strigil strong, also the caudal tibial spurs, the latter unequal, not enlarged especially. Legs moderate. Head wider than the thorax, the vertex wide, the antennæ inserted near the clypeus, 11-jointed with one-minute ring-joint, the five funicle joints enlarging distad, the wider, large-ovate club nearly as long as the funicle. Mandibles palmately 4-dentate. Maxillary palpi 4-jointed. Scutellum with a lateral groove like the *second* one of the *Tetrastichini*. Head somewhat longer than wide.

The male differs in having the antennæ filiform, 12-jointed with two minute ring-joints, the funicle 6-jointed, the club 2-jointed and terminating in an obtuse nipple; funicle and club joints clothed with long soft hairs, more or less 2-whorled (less numerous in the female).

Parecrizotes marylandensis new species. Genotype.

Female: Length, 1.00 mm.

Lustrous black, the head and thorax distinctly scaly; cephalic knees, proximal one or two tarsal joints, a band at base of caudal tibia and apex of scape, silvery white. Wings hyaline, the venation dusky pallid, the swelling of the marginal vein black. Mandibles reddish yellow at apex, the teeth decreasing in size from the first, acute. Pedicel a little longer than wide, slightly larger than funicle 5 which is a little wider than long; funicles 1–3 like large ring-joints but much larger than the real ring-joint; 4 not much smaller than 5. Club without a terminal nipple.

The male differs in having the entire scape black; funicle 1 is largest, cup-shaped, 4–6 twice wider than long. Club nearly equally divided. Last joint of maxillary palpus elongate, equal to the other three taken together.

Described from one male, three females captured by sweeping meadows, September 28, 1915, at Hillmead, Prince George County, Maryland. A rather common species. There is a pair in the U. S. N. M., labelled "*Henicetrus annulipes* Ashmead, Virginia, October 10, 1880," and a female labelled "*virginiensis* Ashmead, Arlington, Va., June 1884."

Types: Catalogue No. 19945, U. S. N. M., a female on a tag plus a slide bearing a pair, a male and female head and female caudal tibiæ. The types were collected in the Maryland locality.

Roptrocerus rectus Provancher.

A number of specimens of both sexes, Ithaca, New York, reared in connection with *Ips pini*, July. There is considerable variation in color; the antennæ may be reddish brown nearly to the club, the ovipositor all black, the legs all yellow brown except the coxæ. The caudal legs are usually metallic, the caudal tibiæ with a broad yellow band just below the knee.

The male is much smaller and has a rather narrow yellow stripe across the abdomen very near base; its antennæ are filiform, 13-jointed with *two* ring-joints; funicle 1 is about twice longer than wide, longest of the flagellum while 6 is a half longer than wide or nearly, longer than the short pedicel. Otherwise about as in the female. The marginal vein in both sexes is thicker proximad, somewhat as in *Muscidifurax* but not so noticeably. A female from Michigan bore no carinæ on the propodeum.

An unstable, widely distributed species probably introduced from Europe.

Achrysocharella obscurinotata new species.

Female: Length, about 0.90 mm.

Bright golden yellow, the wings hyaline, the antennæ black except proximal three-fourths of the scape dorsad; the other portion of the scape and the pedicel dusky, the latter yellowish at apex. Valves of the ovipositor extruded slightly, black. Abdomen above with four small transverse dusky spots, along each side of the meson (thus four pairs or eight in all), the first smallest, some little distance out from base, the fourth at about middle and widest apart from its reciprocal, about twice wider than long, 1 barely wider than long, absent in one specimen. Scutellum with two black bristles distad, the scutum with four in a rectangle, the caudal two longest. Mandibles with three spreading teeth, long, pale, reddish at apex. Postmarginal vein subequal in length to the stigmal. Propodeum noncarinate. Pedicel nearly a half longer than wide, subequal to funicle 2, funicle 1 nearly twice longer than wide; club joints nearly equal, each a little shorter than the funicle 2, club 3 with a distinct terminal nipple which is not half of its length. Flagellum with long, scattered hairs, some stout, mostly very slender. Head and thorax scaly. Parapsidal furrows incomplete.

Described from two females captured by sweeping *Solidago*, Eupatoria and so forth, September 27, 1915, at Hillmead, Glenndale, Prince George County, Maryland.

Types: Catalogue No. 19946, U. S. N. M., the above specimens on tags, the two heads on a slide.

Eupelminus coleopterophagus new species.

Female: Length, 2.50 mm., excluding the ovipositor which is extruded a fourth the length of the abdomen and is white centrally.

Differs from *meteori* Gahan in having most of the thorax metallic; from *dryorhizoxenii* Ashmead about the same; the body is slenderer than with either of these species; from an identified female of *epicaste* Walker in having the ovipositor somewhat shorter, the scutum entirely metallic mesad, the legs lighter in places, the pedicel longer.

Subapterous, the distal half of the small wings fuscous. Metallic green, the abdomen dark purple, encircled at base by a broad silvery band. The following parts reddish yellow: Scape, axillæ, basal third of scutellum, lateral ridges of the scutum, propleurum, proventer cephalad, mesopleurum cephalad, tarsi, cephalic femora and tibiæ interiorly, tips of tibiæ and middle femora except above. White part of valves of the ovipositor somewhat longer than either black part, the latter short. Scutum without a median ridge. Funicle 1 somewhat wider than long, 3 and 4 longest, subequal to each other and to the pedicel, 2 twice longer than wide, a little shorter than 3, 7 quadrate, 8 slightly wider than long. Scape not compressed. Axillæ a little separated. Head and thorax scaly, Scutellum plane. No raised area mesad on cephalic scutum. Segments of abdomen caudad excised slightly at the meson.

Described from four females reared in connection with the strawberry weevil, St. Paul, Minnesota (S. Marcovitch).

Types: Catalogue No. 19947, U. S. N. M., the above specimens on two tags, a head on a slide.

Eupelmus neomexicanus new species.

Female: Length, 2.60 mm., the ovipositor just projecting beyond the tip of the abdomen, white.

Dark metallic green, the wings hyaline; legs, prepectus, mesopleurum and a moderately broad stripe across the abdomen just out from base but more or less distinct, reddish yellow. Venation pale yellowish. Tarsi white, the last joint dusky. Tip of caudal tibiæ, white. Postmarginal and stigmal veins subequal. Antennæ black, the scape not noticeably compressed; funicle 1 somewhat longer than wide, 3 and 4 longest, subequal, neither as long as the pedicel which is over 2½ times longer than wide at apex; funicle 2 a third longer than wide, 3 twice longer than wide; 8 slightly wider than long. Head and thorax finely scaly, the axillæ and scutellum uniformly coarser. Abdomen scaly like the scutum, the latter with a lateral ridge but no median (or else it is very obscure and delicate). Raised, triangular part of the scutum cephalad not with a different sculpture. Segment 2 of abdomen deeply incised at meson of its caudal margin, the following segments less and less so.

Described from two females in the U. S. N. M., labelled "Las Cruces, New Mexico."

Types: Catalogue No. 19948, U. S. N. M., the above specimens on tags plus a slide with fore wings and antennæ.

Hemænasoidea new genus.

Female: In my table of the earth's encyrtine genera runs to *Hemænasius* Ashmead but differs from that genus in having the head much longer than wide, the eyes very long, six times longer than the distinct yet short cheeks, the head lenticular, the frons moderately narrow. Mandibles with three acute teeth, the first two equal, the third short. Ovipositor extruded nearly half the length of the abdomen. Marginal vein slightly longer than wide; the postmarginal moderately long but somewhat shorter than the stigmal. Hairless line of fore wing narrow. Axillæ barely separated.

Hemænasoidea oculata new species.

Female: Length, about 1.75 mm., excluding the ovipositor.

Dull honey yellow, the following embrowned parts: Center of cephalic pronotum, scutum, abdomen, tip of ovipositor valves, tibiæ except at ends (caudal tibiæ much darker, purplish), scape, pedicel and funicles 1–2. Fore wings embrowned at base and from the bend of the submarginal vein distad to about a point as far distad of the apex of the stigmal vein as that vein is long; this central infuscation is followed by a discal (longer than wide) naked area inclosed by discal cilia; otherwise the fore wing very finely ciliate discally but naked between the two infuscations. Venation dusky yellow, Scape reaching to the cephalic ocellus, cylindrical, the pedicel two and a half times longer than wide at apex, longer than any funicle joint; funicle 1 longest, a half longer than wide, 5 slightly longer than wide, 6 quadrate. Club about half the length of the funicle, obliquely truncate, not enlarged. Body finely scaly. Scutellum with a few scattered, rather coarse hairs. Pronotum moderately large. Axillæ large. Legs slender. Middle femora, tarsi (except last joint), ovipositor valves (except at apex) and antennæ distad, whitish. Club truncate from base of joint 1.

Described from a female on a slide in the U. S. N. M., labelled "Reared from *Pseudococcus citri* on bamboo, Manila, Compere, July, 1909. No. 24.

Type: Catalogue No. 19949, U. S. N. M., the above specimen on a slide.

OBSERVATIONS ON THE LIFE HISTORY OF PTERODONTIA FLAVIPES GRAY. (DIPTERA.)*

By J. L. King, Wooster, Ohio.

INTRODUCTION.

During the summer of 1915, while at Gypsum in northern Ohio, the writer found several peculiar dipterous larvæ under burlap bands which had been placed around the trunks of some apple trees. The adults reared from these proved to belong to the genus Pterodontia of the family Cyrtidæ. From the literature at hand it was evident that little had been published concerning the habits of this interesting family. This stimulated further observation, the results of which are recorded in this paper. Later a more thorough study of the literature was made, particularly of those articles which deal with the life histories of the members of the family. These have been briefly summarized and are appended after each special topic.

The writer wishes to express his gratitude to Professor A. D. MacGillivray for his kind interest and help in the preparation of this paper. Thanks are also due to Mr. J. R. Malloch, of the Illinois State Laboratory of Natural History for the identification of the species, and to Mr. Nathan Banks for the determination of the host spiders.

THE MATURE LARVA OF PTERODONTIA.

On July 20, 1915, three larvæ were found under the burlap bands which surrounded the trunks of some large apple trees. In all cases the larvæ were found either suspended in abandoned spider webs or entangled by threads and resting partly on the bark or on the burlap. When suspended, their position was maintained by the web adhering to their sticky body surface. In two cases the remains of spiders were found near the larvæ. The largest larva, measuring 8 mm. in length, had emerged from the abdomen of an Epeirid spider, *Epeira sericata* Clerk, leaving the abdomen through a comparatively small hole on the ventral side, in the region of the anterior lung-slit. From the size of the larva and the scant remains of the abdomen, it would seem that the larva had almost filled the entire abdomen. The cephalothorax and legs were also eaten out so that the remains resembled a cast skin, except for the fact that the cephalothorax was not broken. The smallest larva, which was 6 mm. in length, had emerged under similar conditions but from a smaller spider. In the third case no remains of a spider were noted.

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*Contribution from the Entomological Laboratories of the University of Illinois, No. 49, and the Ohio Experiment Station, Wooster, Ohio.

Since the foregoing notes were written, five larvæ of this species have been found to be parasites of Lycosid spiders. Concerning the identity of these, Mr. Nathan Banks states that he is almost certain the species is *Lycosa pratensis* Emer., the doubt of the question being due to the partial destruction of the specimens by the parasites.

The larvæ vary in length from 6 to 8 mm. and are oval in form with a strong constriction marking off the smaller cephalic end (Fig. 8). They are of a creamy white color and on the dorso-meson show four dark areas which pulsate in a slow, rhythmic manner. The body-wall is soft and delicate, the external surface being smooth and sticky, causing the web and small particles of dirt to adhere to it. The segmentation of the body is not very distinct; however, the cast skins show twelve body segments. The four anterior segments are not as well defined as the others and seem to be softer and more delicate. The second segment bears a pair of closed spiracles which connect with large tracheal tubes. On the ventral surface of the fifth to the eleventh segments are seven pairs of padlike areas which are armed with minute crotchets. The caudal spiracles are located on the dorsal surface of the twelfth, or caudal, segment. They are larger than the anterior spiracles and have a distinct opening. In the living larva they are capable of being slightly extended or retracted.

The mouth-parts have been studied from cast larval skins. The external mouth-parts consist of two minute bidentate mandibles, and two mouth-hooks (Fig. 8a, m. and m. h.). These structures are attached on each side of the small mouth opening. The internal structure consists of a pharyngeal plate in the form of a shallow trough with two curved anterior arms which meet and form a circular loop above the mouth cavity (Fig. 8a, ph. p.). Attached to the margins of the pharyngeal plate and loop is a tough membrane which forms the dorsal roof of the pharynx. Whether muscular attachment converts this structure into a pharyngeal pump or whether further parts are wanting cannot be determined until additional material is at hand.

LITERATURE ON THE LATE LARVAL STAGES OF THE CYRTIDÆ.

In Europe Menge (15)* in 1863 was the first to record that the Cyrtidæ are parasitic in the bodies of spiders. He obtained from the nest of a spider, *Clubiona putris*, a larva which proved to be that of *Oncodes pallipes* Erich. (*Henops marginatus*). Further examination of the nest of the spider revealed the shriveled remains of the spider with a large hole in the underside of the abdomen. Brauer (2) in 1869 described and figured the larva and pupa of *Astomella lindenii*, which were found in the burrow of a spider, *Ctenzia ariana*. According to Brauer's (3) observations, the larvæ, while lodged within the abdomen of the host, breathe by placing their caudal spiracles in one of the lung-chambers of the spider. The fully grown larva of *Astomella lindenii* is 10 mm. in length and is comparatively thick. The body has twelve segments. The head segment is small and is fitted with mandibles and maxillæ. The larva is amphipneustic, having prothoracic and caudal spiracles.

In the United States several observers have recorded the finding of Cyrtid larvæ, though they have given us no detailed descriptions of them. Among the most important of these are Emerton's (4) observations on the larvæ of *Acrocea lasciata* Wied. The larvæ were found clinging to the deserted webs of *Amaurobius sylvestris*. They were suspended in the webs, heads uppermost, clinging to it with their jaws and also supported by threads under and around them. The shriveled remains of the spiders were found in the webs. The larvæ are described as soft, white maggots from one-eighth to one-fourth of an inch in length with the hinder half of the body thicker than the front half and nearly spherical. A single figure of the larva is shown. Johnson (7) in 1903 is reported as having reared the same species from *Lycosa stoni*. He states that many spiders, perhaps twenty-five per cent, are parasitized by these flies. Montgomery (16) in 1903 records the occurrence of Cyrtid larvæ as parasitic in spiders of the genus Lycosa which he had under observation. One male and six female spiders were found to be parasitized and in one case two larvæ issued from a single spider. This observer notes that a short time before the parasite escapes from the body of its host, the spider acts in a peculiar manner, walking about spasmodically and often spinning aimlessly. After the soft parts of the body of the spider are eaten away the parasite emerges through a hole which it makes in the abdomen; this emergence kills the host. The bulk of the body of each parasite is noted as being almost equal to that of the abdomen of the host.

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*Numbers refer to the bibliography, page 000.

THE PUPA OF PTERODONTIA.

The pupation of the larvæ took place July 21, or the day after the larvæ left their hosts. The pupa (Fig. 9) was 6 mm. in length and when first formed was light creamy-white, but soon after it turned to a pale yellowish-brown color. The surface is smooth, shining, and without setæ or spines except for a prominent V-shaped crest on the head. This is composed of a large number of irregularly barbed, clublike processes (Fig. 9a). The various adult parts, as the rounded head which is quite prominent, the wings, tegulæ and legs are quite distinctly outlined in the pupa. On the cephalo-lateral aspect of the thorax there is a single pair of spiracular projections and caudad of these the thorax is elevated into a rounded hump. The abdomen consists of eight segments, the anterior three each bearing a pair of elevated spiracles. The caudal segments are telescoped into the preceding segments, giving the abdomen a truncated appearance. The lateral line caudad of the third spiracle is marked by a dark furrow. The duration of the pupal period was seven days.

LITERATURE ON THE PUPÆ OF THE CYRTIDÆ.

The pupa of *Astomella lindenii* has been described by Brauer (2). It differs from the pupa of Pterodontia in several characteristics; namely, the head is less prominent and lacks the crest of spines; the thorax bears on the dorso-meson a row of spines. The abdomen shows seven segments, the first six of which bear spiracles. The empty pupal case is dark brown spotted with light yellow.

Of the American species the pupa of *Oncodes costatus* Loew is described by Malloch (12). The description was made from a single pupal exuvium. In most respects the pupa seemed to be similar to that of Pterodontia but differs in having five spiracles; the anterior four are on prominent protuberances. The crest of barbed spines is also wanting in this species.

THE ADULT.

Female.—(Fig. 1) Head spherical and small in proportion to the thorax. Eyes contiguous, large, black, and densely clothed with long, black setæ. Ocelli three in number. Antennæ inserted ventrad of the compound eyes; they consist of three segments, the third of which bears three or four terminal setæ. The mouth-parts are obsolete. Thorax large, mesonotum piceous and shining; scutellum light yellow or sometimes light brown. Ventral parts of thorax dark brown. The entire thorax is clothed with long, black hairlike setæ. Legs pale yellow except the femora which are somewhat darker yellow or brownish. Tegulæ large and brownish in color. Wings slightly clouded, membrane undate, veins dark yellow or brown. Venation as shown in Figure 3. The toothlike projection near the distal end of the costal margin is wanting in the female. Abdomen large, globular and inflated. First abdominal segment black or brownish. Second abdominal segment yellow or testaceous and with the cephalic margin black; in some individuals this segment has a median triangular black spot. The third segment in most specimens is entirely yellow or testaceous; however, a few specimens have a median, black, triangular spot on the cephalic margin. The remaining segments are yellow or testaceous. Ventral surface of abdomen dark brown. The entire surface of the abdomen is clothed with long, black, hairlike setæ. The length varies from 4 to 8 mm. with an average of 6.5 mm. taken from a series of twenty-six females.

Male.—The male differs from the female in the following points: Thorax broad and more robust than that of the female. Four posterior femora black. Wing veins yellow, toothlike projection on the costal margin prominent (Fig. 3). Second abdominal segment shining black. Third segment testaceous and with a large median rectangular spot. Fourth segment testaceous but sometimes with a median oval black spot. The remaining segments are testaceous (Fig. 2). Length 6 to 9 mm., average about 7 mm.

A closely allied western species of this genus has been described by Osten Sacken (17). This species, *Pterodontia misella*, so closely approaches *Pterodontia flavipes* Gray (6) that it is sometimes difficult to determine to which species a variety may belong. Williston (19) says concerning *P. misella* O. S.: "I have several specimens of this species from Washington varying from six to nine millimeters in length. The black markings of the abdomen vary in extent, and from comparison with eastern specimens (*P. flavipes* Gray), I can find no constant difference and believe them to be the same." From comparisons made by the writer it is noted that the species, *P. misella*, seems to be founded on color pattern alone, for there seems to be no morphological dissimilarity. The only solution to such questions of the identity of a species seems to be by a careful study of a series of specimens which have been reared from known forms.

OVIPOSITION OF PTERODONTIA.

On August 7, while passing by the border of an open hickory grove, the writer observed several large flies hovering up and down the trunks of some large hickory trees. The capture of one of these proved the species to be identical with those reared from the larvæ found on the apple trees. The flies were observed for some time; during this period they hovered up and down the tree trunks from about a foot above the ground to a height of ten to fifteen feet. They flew always on the leeward side and from one to two inches away from the surface of the bark. Occasionally they would come to rest upon the bark, and at such times they were so sluggish that it was possible to pick them up in one's fingers. Though the flies were observed very closely. they were not seen to deposit eggs or to pay any attention to the gray jumping spiders that crept over the bark.

Upon returning to the laboratory and transferring a living specimen to a bell-jar, the writer noted that the handkerchief in which it had been carried was sprinkled with minute black specks, which on examination proved to be eggs. Further observation revealed the fact that the eggs were forcibly discharged from the ovipositor in extremely rapid succession and that the eggs when first deposited were coated with a sticky substance which caused them to adhere to whatever they hit or fell upon.

The following day some of the trees in the grove were banded with narrow strips of clean, white paper. After a brief period two flies appeared hovering over the surface of the bark in the same manner as observed during the previous day. This time, however, with the aid of the white paper strips, their actions were easily interpreted. By watching closely as the flies hovered over the paper strips, one could see the eggs appear upon the paper as minute black specks sprinkled in irregular rows. An examination of the bark of the trees showed the leeward side of each tree to be literally sprinkled with thousands of eggs. One of the ovipositing flies was so bold as to hurl her eggs on to the face and hands of the writer while making these observations.

The eggs contained in the handkerchief were removed to a watch glass by means of a soft brush. Many of the eggs were lost or crushed during the process; however those remaining numbered 2,300. All of these were deposited by a single female in a period of not more than forty-five minutes.

A second series of egg counts has been made from three females taken July 14, 1916. The counts represent the entire number of eggs deposited by each female from the time of capture until death. They are as follows: No. one, 987; No. two, 3,344; and No. three, 3,977. Most of these eggs were deposited during the morning of the first day, and in no case did the captive flies live for more than two days.

THE EGGS OF PTERODONTIA.

The eggs (Figs. 4 and 5) are very minute, measuring .18 mm. in length and .15 mm. in width. They are slightly compressed and pear-shaped in outline and are of a dull black color. Under high magnification the chorion has a granular appearance as shown in Figure 6. When first deposited, the eggs are coated with an adhesive substance.

LITERATURE ON THE OVIPOSITION AND EGGS OF THE CYRTIDÆ.

Brief notes are to be found concerning the eggs of several European species. Friedrick Stein (18) in 1849 records finding the eggs of *Oncodes fuliginosus* Erich. in mid-June on the stems of *Equisetum limosum* which was growing in a low, wet meadow not far from Berlin. The eggs had been despoited in rows in large numbers and covered the plants thickly. The eggs are described as small, black, pear-shaped bodies. In 1894 König (10) described the eggs and young larvæ of what he thought were those of either *Oncodes gibbosus* or *O. zonatus*, since he took both species in the same locality. The eggs had been deposited on dead branches which had been used to make a fence. The smallest twigs were thickly covered with rows of dark brown or blackish, pear-shaped eggs deposited so as to stand on the small end. The larvæ emerged from the free end of the egg through a lidlike opening in the shell.

An interesting note on the oviposition of a New Zealand species, *Oncodes brunneus* Hut. (*Henops brunneus*), is given by W. M. Maskell (13) as follows: "About October last a resident in the Wairarapa District sent down to the Colonial Museum a few twigs of apple, quite covered with some black substance, amongst which were slowly crawling about half a dozen rather large flies; and he desired some information on this, which he considered a new 'blight,' stating that it occurred on both apple and peach trees in his garden. The specimens were referred to me, and at first sight I thought the sooty, black coating to be the usual fungus accompanying scale insects, the flies being unconnected with it. Closer examination, however, showed that the black mass was really composed of many thousands of eggs; and the flies were soon observed to be still laying more of these eggs on the twigs, until in a short while it was so thickly covered with them as to be quite hidden."

THE NEWLY HATCHED LARVA OF PTERODONTIA.

From eggs which were deposited on August 7th, larvæ emerged September 7th and 8th, thus making an incubation period of 32 to 33 days. The larvæ made their exit through a lidlike opening at the small, or pointed, end of the eggs. The newly hatched larvæ (Figs. 11 and 12) are Campodea-like in form, resembling quite strikingly the planidium larvæ of Perilampus* or the triungulin larvæ of Stylops. They are dark brown or black in color and measure 0.25 mm. in length, exclusive of the caudal setæ. The body consists of twelve segments including the head.

The head segment is distinct though it is firmly joined to the prothoracic segment. The head appendages consist of two ventral mouth-hooks and two caudo-lateral antennalike setæ. The details of the mouth-parts have not been worked out. There is, however, a large internal pharyngeal skeleton which is very distinct. The latter structure consists of two strongly chitinized dorsal plates (Figs. 7 and 11) and a slightly chitinized ventral plate, which is visible only in a lateral view (Fig. 7). The pharyngeal plates seem to fuse and form a median tooth or beaklike rostrum which is capable of being slightly protruded.

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*See Smith, H. S. The Chalcidoid genus Perilampus and its relations to the problem of parasite introduction. U. S. Dept. Agr. Bur. Ent., Tech. Series No. 19, 1912, pp. 33–69.

The thoracic and abdominal segments are strongly chitinized and consist of distinct tergal and sternal plates. In newly hatched larvæ the body-plates and segments are quite closely drawn together, but in specimens which were removed from their hosts the segments were distended, the terga and sterna being separated by a pleural membrane (Fig. 7). The dorsal and ventral surfaces of the thorax and abdomen are elaborately armed with long and short spines and broad chitinous scales. The dorsal scales are broad and palmate, with nine to eleven points (Figs. 13 and 14). On the dorsum they are limited to the mesothoracic and metathoracic terga, the remaining segments being armed with both long and short spines. There are also a number of minute, round, clear spots, which occur only on the terga. On the venter, the scales occur on all of the sterna except the prothoracic and caudal segments. On the sterna of the second and third thoracic segments and the first abdominal segment the scales are broad and have seven points or digits; the remaining segments are armed with smaller scales which for the most part are three, five, and seven pointed. The scales are firmly set into the body-wall through a funnellike opening (Fig. 16). The caudal end of the eighth abdominal segment is membranous and prolonged, forming a disk or sucker which serves for attachment. On each side of the caudal disk is a long, stiff, spring-bristle which is used in leaping. Spiracles seem to be wanting. On the caudal margin of the eighth abdominal terga are two crescentic areas which resemble spiracles. These, however, are notches in which the caudal setæ, or spring-bristles, rest when the larva stands erect on its attachment disk.

HABITS OF THE LARVA.

The young larvæ are very active, particularly at night when they are in almost constant action. Locomotion is accomplished in several ways. There is a looping movement accomplished by attaching first the head and then the attachment disk in a manner similar to that of a leech. A second method, that of leaping, is effected by the larva standing erect on the attachment disk with the spring-bristles bent at right angles to the body and toward the dorsal surface; when ready to leap a sudden straightening of the setæ in a posterior direction lifts the larva into the air. In this way the larva can leap five or six millimeters. This method of jumping is quite different from that of the cheese-maggot, *Piophila casei*, and some of the Itonididæ which leap by first bringing the head and tail ends together and then suddenly straightening the body. A third method of locomotion occurs when the larvæ are on a moist surface, when they crawl by extending and contracting the body segments.

On September 10th, the larvæ were separated into two lots and were liberated in large petri dishes which contained bark. A few spiders of the genus Epeira and spider's eggs were also placed in the dishes with the larvæ. In both dishes most of the larvæ died after three days and in five days no living larvæ were found, though the spiders seemed to be normal and fed upon flies for several days.

On September 27th, or 17 days after confinement, one of the smallest spiders was found in a dying condition. The abdomen of this specimen was removed and carefully dissected. Three spiny larvæ were found in the body near the dorsal surface. The larvæ were alive and active and showed no change other than a distension of the body segments.

Some time later the cephalothorax and legs of this same spider were cleared in carbol-xyol and mounted in balsam. This method rendered the thorax almost transparent and enabled one to locate the parasites in their exact position. In all, twenty-seven larvæ were found in the cephalothorax and legs. These were found in the following parts: One in the first segment of the right palp, one in each trochanter of the anterior pair of legs, two in the trochanter of the second right leg, one in the femur of the third right leg, one in the femur of the fourth left leg, one in the patella of the fourth left leg, and the remaining nineteen were in the cephalothorax above the ental openings of the coxæ or near them (Fig. 10).

On November 29, 1915, a second spider died. The death of this specimen was doubtless due to injury received while moving the specimen from Ohio to Illinois, for the thorax was dented and one leg partly crushed; however, it lived for seventy-nine days after it had been put with the young Cyrtid larvæ. This specimen was too large to clear; hence the entire spider was immediately dissected. One spiny larva was found in the abdomen and three in the thorax. As in the first case, the larvæ were alive and active but no change had taken place. All of these larvæ were carefully examined, and in all cases the spines and scales of the body and the caudal setæ were found to be intact.

Although the foregoing cases of parasitism were brought about under abnormal conditions in the presence of hundreds of larvæ, they manifest several interesting points: First, it would seem from the large number of larvæ found in the cephalothorax thorax and legs of the host that most of the larvæ enter the body of the spider by penetrating the thin membrane at the articulations of the legs. The broad scalelike plates and spines undoubtedly enable the larvæ to penetrate the host and aid in traveling through the muscles of the thorax. Second, the occurrence of first-stage larvæ in the host seventy-nine days after entering, and during November, would lead to the conclusion that the growth of the parasite does not start until after the hibernating season of the host is over. Third, the location of the larvæ in the cephalothorax thorax further indicates that the first-stage larvæ do not have any connection with the respiratory organs of the host. This is further confirmed by the lack of spiracles.

LITERATURE ON THE EARLY LARVAL STAGES OF THE CYRTIDÆ.

Very little has been published concerning the early larval stages of the species of this family and as far as could be ascertained none of the American species have been described. Of the European species only the larvæ of Oncodes have been described. Professor Brauer (2) in quoting from his correspondent, Dr. Gerstacker, states that this observer reared larvæ from the eggs of *Oncodes zonatus*. He does not describe the larvæ further than to say that they were very active and sprang like the cheese-maggot, *Piophila casei*. In 1894, König (10) found eggs and young larvæ of Oncodes. The exact identity of the larvæ is not certain, though he took the species to be either *O. gibbosus* or *O. zonatus*, since adults of both species were taken in the same locality. The larvæ are figured and described in detail. They are described as being 0.3–0.4 mm. long and of a dark brown or black color. The body is made up of eleven distinct segments, and is armed with setæ. The head is small and not well defined. The mouth-parts consist of two external mouth-hooks, a median tooth and two fleshy lobes, the latter functioning as attaching organs. There are two internal pharyngeal plates. On the caudal segment is a second attaching organ and four short spring-bristles; thus the larvæ move about by a looping movement or by jumping. König states that some of the larvæ were found attached to Podurans.

The larva of a New Zealand species of Oncodes has been figured and described by Maskell (13) in 1888. The larvæ are similar to those described by König. They differ from them, however, in the following points: The body is made up of twelve segments and the head is distinct. There are two mouth-hooks and a fleshy lobe which functions as an attachment organ. The caudal segment terminates in a point with three spines. There are two stout spring bristles and the penultimate segment has two spiracles. The larvæ are said to walk in a looping fashion.

CONCLUSIONS.

From the account herein presented, we may conclude that the method of oviposition of *Pterodontia flavipes* is unique; however, the potential reproductive power of the females seems to be common with other members of the family, as is illustrated by the observations of Stein (18), König (10) and Maskell (13). It is undoubtedly one of the adaptations exacted by a parasitic mode of life in which there is a large percentage of mortality in the first larval stages.

In general the activities of the newly hatched larvæ of Pterodontia are like those of Oncodes. However, morphologically, they are more highly specialized for their parasitic mode of life, as is manifest by the lack of spiracles and by the presence of elaborate scalelike plates on the body.

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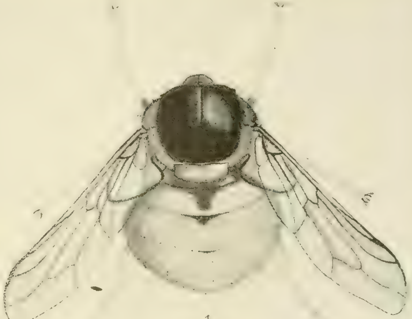
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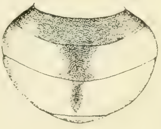
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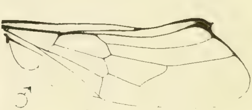
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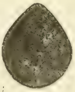
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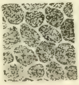
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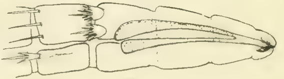
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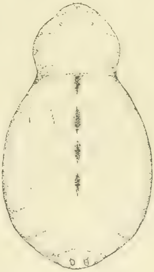
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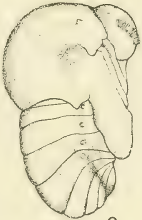
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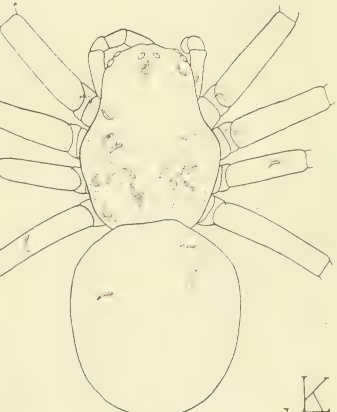
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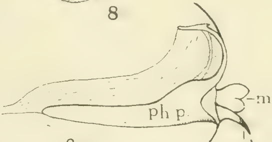

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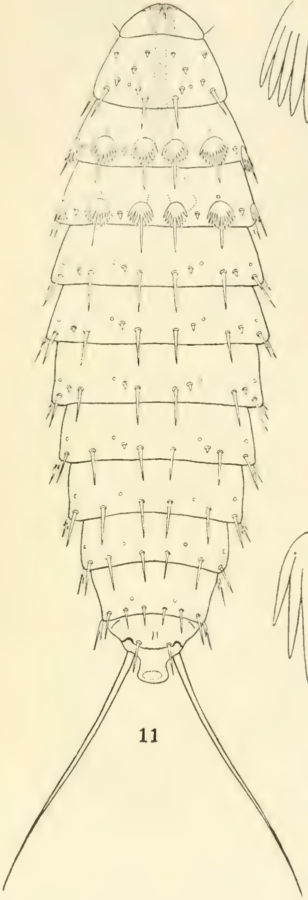

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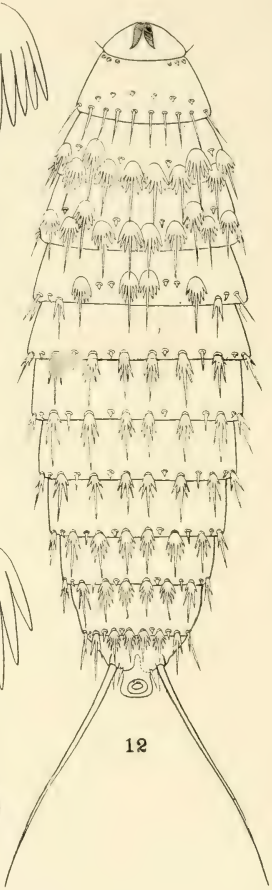

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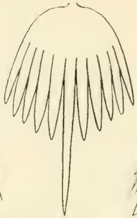

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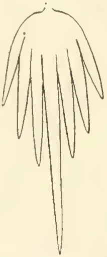

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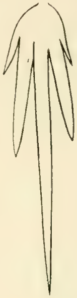

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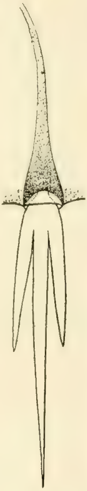

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EXPLANATION OF PLATE XV.

Pterodontia flavipes.

1. Dorsal aspect of female.
2. Dorsal aspect of male abdomen.
3. Wing of male.
4. Egg as viewed from the side.
5. Egg as viewed from above.
6. Chorion highly magnified.
7. Lateral aspect of young larva showing mouth-hooks and internal pharyngeal skeleton.
8. Dorsal aspect of mature larva as it appears after emerging from host spider.

8a. Lateral aspect of mouth-parts, m., mandible; m. h., mouth-hooks; ph. p., pharyngeal plate.

9. Lateral aspect of pupa.

9a. Clublike processes from head of the pupa.

10. Young larvae in the body of Epeirid spider.

EXPLANATION OF PLATE XVI.

Pterodontia flavipes.

11. Dorsal aspect of newly hatched larva.
12. Ventral aspect of newly hatched larva.
13. Scale from mesonotum.
14. Scale from mesosternum.
15. Scale from sternum of third abdominal segment.
16. Scale from sternum of seventh abdominal segment showing its insertion.

THOMAS SAY FOUNDATION.

The Foundation announces the acceptance for publication of its first volume, "The North American Species of Sarcophaga and Allied Genera," by J. M. Aldrich. The volume will be printed in time for presentation at the New York meeting of the Society in the holidays. It will make a volume of over three hundred pages with 170 figures on sixteen plates. One hundred and forty-five species are described, most of which are new, the genitalia of 138 species are figured. Many new records of larval habits are given.

The Committee of the Foundation sent to each member of the Entomological Society of America during the summer of 1915 a request for ten-dollar subscriptions, to which replies were received from only seventeen members. The text of that letter and the subscription form are printed on page 110 of the March number of the present volume of the ANNALS. In order to finance the publication of this volume, subscriptions are needed from a much larger number of members. The Committee feels that the limited number of replies was probably due to the fact that there was no immediate prospect of any publishing being done. The first volume is now in the printer's hands and the present is an opportune time for the members of the Society to come to the support of the Foundation with ten-dollar subscriptions. The members of the Foundation are advancing several hundred dollars in the publication of this volume. Will you not aid us by sending subscriptions to Morgan Hebard, Treasurer, Chestnut Hill, Philadelphia, Penn.?

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Volume IX. Number 4.

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ANNALS

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The Entomological Society of America

Volume IX DECEMBER, 1916 Number 4

NOTES ON NORTH AMERICAN DROSOPHILIDAE WITH DESCRIPTIONS OF TWENTY-THREE NEW SPECIES.

A. H. STURTEVANT, Columbia University.

The writer has in preparation a comprehensive treatment of the North American species of Drosophila and closely related genera. This paper is not yet ready for publication; but there are several unnamed species that are being used as laboratory animals, so it has seemed advisable to put out a preliminary paper describing these and other new forms, and revising the names of a few additional species.

In the following descriptions there are a few terms that will need explanation. The "number of rows of acrostichal hairs" is to be counted just in front of the anterior pair of dorsocentral macrochætæ. The "costal index" is the number obtained by dividing the length of the second section of the costa by that of the third section; the "4th vein index" is obtained by dividing the length of the ultimate section of the fourth vein by that of the penultimate section; the "5x index" is obtained by dividing the length of the last section of the fifth vein by the length of the posterior cross-vein; the "4c index" is obtained by dividing the length of the third section of the costa by that of the penultimate section of the fourth vein. These indices are somewhat variable, but nevertheless are sufficiently characteristic to be valuable aids in classification. I hope later to publish some detailed data on their variability.

In the cases of four new species (*Drosophila virilis, robusta melanica, and modesta*) I have reared offspring from the individual selected as the type specimen. In these cases the mate, to which the type was bred, is designated allotype; and all descendants of the type are called *gonotypes*.

My studies have been greatly facilitated by loans of material and other favors received from Dr. F. E. Lutz, Messrs. C. W. Johnson and F. Knab, and Profs. J. M. Aldrich and A. L. Melander, and others. To them I wish to express my most sincere thanks.

The type specimens of the new species described here are in the following collections:

American Museum of Natural History, New York City:
Drosophila ramsdeni, saltans, earlei, virilis, robusta, melanica, melanissima, affinis, caribea, cardini, modesta, putrida, floræ, lutzii, prognatha, quadrata.

United States National Museum, Washington, D. C.:
Drosophila sulcata, pseudomelanica, orbitalis, superba, projectans.

A. L. Melander:
Drosophila melanderi.

J. M. Aldrich:
Chymomyza aldrichii.

Many paratypes are in the author's collection, in the four named above, and in other collections.

Leucophenga Mik. 1886. Wien. Ent. Zt. 317.

Drosophila maculosa Coq. 1895, Proc. Acad. Nat. Sci. Phila. XL, is a synonym of *L. quadrimaculata* Walk. 1856, Dipt. Saund. IV. The species will be easily recognized by its large flat yellow palpi. I have seen specimens from New York, District of Columbia, North Carolina, Florida, Cuba, Dominican Republic, Peru. These include Coquillett's type.

Drosophila bimaculata Lw. from Cuba, is a *Leucophenga.* I have examined Loew's specimen in the Museum of Comparative Zoology at Harvard, and two Cuban specimens in my own collection.

"*Leucophenga vittata* Coq." of Johnson, 1913, Bull. Am. Mus. Nat. Hist. XXXII. 88 is a *Scaptomyza*. (See below).

Chymomyza Czerny. 1903. Zts. Hymenopt. III.

This genus has not hitherto been reported from North America, but *Drosophila amœna* Lw. and *D. procnemis* Willist. both belong here. The genus is easily separable from *Drosophila* in that it has bare eyes; small postvertical bristles; second orbital small or missing; a fourth orbital, below the third, large, and reclinate; prominent male genitalia. The species are usually rather slender, often with pigmented wings, and have the habit of waving their wings. They are frequently found around bleeding trees, but *C. amœna* and *C. procnemis* will breed on fermenting fruit. *C. amœna* is frequently collected with the sweeping net, and is often very common around tomatoes and windfall apples. It is also often seen on windows. *C. procnemis* occurs from New York to Trinidad and Panama.

C. caudatula Oldenberg, 1914, Arch. Naturgesch. LXXX, A. Heft 2, 14, was described from Herkulesbad, in the southern Carpathians. Prof. Melander lent me two specimens, collected at Pullman and at Mt. Constitution, both in Washington. I have carefully compared these specimens with Oldenberg's very full description, and can find no significant difference, even in the external male genitalia. There is, so far as I am aware, no other record of the species.

The three species above, with the new one described below, may be separated by the following key:

1. Wings much spotted; front legs yellow........................*C. amœna* Loew.
   Wings clear, or blackish along anterior margin, or with a white tip; front femora, tibiæ, and first tarsal joints blackish..............................2
2. Front dark opaque brown..3
   Front yellow or reddish yellow........................*C. procnemis* Williston
3. Wings clear; face whitish............................*C. caudatula* Oldenberg
   Costal cell brown; face brown..............................*C. aldrichii* n. sp.

Chymomyza aldrichii, n. sp.

♂. Arista with four branches above and two below. Antennæ reddish brown. Front nearly one-half width of head, wider above; reddish brown, orbits and triangle darker. Second orbital reduced to a minute hair, the other three approximately equal in size. Carina very small and confined to upper part of face. Face brown, somewhat concave. There is a row of bristles on the oral margin, the anterior one being slightly longer than the others. Cheeks yellow. Eyes bare.

Dorsum of thorax and scutellum shining dark reddish brown. Pleuræ brownish yellow. Coxæ and legs pale yellow, except as follows; fore femora and tibiæ dark brown, fore tarsi and hind tibiæ brownish yellow.

Abdomen shining black, hypopygium prominent.

Wings brownish on anterior margin, especially in costal cell. Costal index about 1.9, 4th vein index about 2.6, 5x index about 2.0, 4c index about 0.6.

Length of body 2¼mm., wings 2½mm.

Type and 7 paratypes, collected at Potlatch, Ida., Sept. 9, 1912, on the windows of a sawmill (J. M. Aldrich). Also one specimen, Yale, Ida., Sept. 10, 1912 (Aldrich). The type and 5 paratypes have been returned to Prof. Aldrich.

Scaptomyza Hardy, 1849. Proc. Berwicksh. Nat. Club, 349.

This genus is easily recognized, in our American species, by the 2 or 4 acrostichal rows. The larvæ are not exclusively leaf miners, as I have bred *S. adusta* Lw. and *S. graminum* Fall. through several generations on tomato fruits and also on potato tubers.

Our species have been separated largely on the basis of the thoracic color and the presence or absence of the spot at the tip of the wings. Both characters are extremely unreliable, however, as neither the dark thorax nor the wing spot appears until a day or two after the adult emerges. The genus is easily divided into two groups on the basis of the number of rows of acrostichal hairs. *S. adusta* Lw. and *S. terminalis* Lw. have 4; *S. graminum* Fall. has 2.

S. flaveola Meig. probably does not occur in North America. Most specimens so labelled seem to be immature specimens of the three above named species. *S. vittata* Coq. 1895 Proc. Acad. Nat. Sci. Phila. 318, is perhaps a synonym of *S. graminum* Fall. Geomyz. 8. I have been unable to find the type specimen of *vittata*. There are some tropical species belonging to the two-rowed group, but I have not described them because of my uncertainty as to most of this genus.

S. apicata Thoms. 1868, Eug. Resa. 597, is probably a synonym of *S. terminalis* Lw. 1863, Berl. Ent. Zt. I have examined a very large series of this form from the Pacific Coast and from Canada and New England, including Loew's specimen. It is extremely variable in several characters (size, color, wing-markings) and there may well be several species involved. Some specimens are practically indistinguishable from *S. adusta* Lw.; but that species is not especially variable, and is much lighter in color than most *S. terminalis*. I have seen specimens of *S. adusta* from Massachusetts, Alabama, Texas, Illinois and numerous intermediate states.

Drosophila Fall, 1823. Geomyz, 4.

The following new names are proposed, those now in use being preoccupied (homonyms).

Drosophila annularis, nom. nov. for **D. annulata** Willist. 1896. Trans Ent. Soc. Lond. Not **Notiphila annulata** Fall. 1813. Vetensk. Akad. Hand.; **Drosophila annulata** Zett., 1847. Dipt. Scand. VI.

Drosophila nebulosa, nom. nov. for **D. limbata** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila limbata** v. Ros. 1840. Württ. Corrbl. The species occurs in Porto Rico, Cuba, Dominican Republic, Barbadoes, Panama.

Drosophila pulchella, nom. nov. for **D. bellula** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila bellula** Bergr. 1894. Ent. Zt. Stett. LV.

Drosophila willistoni, nom. nov. for **D. pallida** Willist. 1896. Trans. Ent. Soc. Lond. Not **Drosophila pallida** Zett. 1847. Dipt. Scand. VI. This species is found in Florida (Miami), Cuba, Jamaica, Hayti, Porto Rico, Bahamas, British Honduras, Costa Rica, Panama and at Manaos, Brazil (?).

Drosophila multipuncta, Lw. 1866. Berl. Ent. Zt. X. is a synonym of **D. guttifera** Walk. 1849. List. Dipt. Ins. IV. I have examined the Loew specimen in the Museum of Comparative Zoology at Harvard, and a large series of more recent material from Massachusetts, New Jersey, North Carolina, Indiana, Alabama and Texas.

Drosophila ornatipennis, Willist. 1896. Trans. Ent. Soc. Lond. is a synonym of **D. calloptera** Schiner. 1868. Novara. I have examined Williston type material in the American Museum of Natural History, and specimens that I collected in Cuba.

"**Drosophila slossonæ** Coq." of Johnson. 1913. Bull Am. Mus. Nat. Hist. XXXII. 88, is a manuscript name, and I have been unable to find any specimen bearing this label.

Drosophila obscura Fall., a common European species, occurs on the Pacific coast. I have examined specimens from Corvallis, Oregon, Claremont and Newport, California. These agree with European material determined by Bezzi and by de Meijere, and with the descriptions given by Schiner and by Oldenberg. The Japanese specimens referred to this species by Coquillett (1899. Proc. U. S. N. M. XXI. 301) are not very well preserved, but I am convinced that they belong to some other species.

Drosophila ramsdeni, n. sp.

♀. Arista with 4 branches above and 2 below. Antennæ pale yellow, third joint reddish brown above. Front pale yellow, 3 brown spots on each orbit, and one around each ocellus. Second orbital one-fourth size of other two. Vibrissa three times size of other oral bristles. Carina large, broad, sulcate. Face and cheeks yellow, a brown spot just below carina; and one just below each eye. Eyes with black pile.

Eight acrostichal rows, no prescutellar bristles. Dorsum of thorax light gray, each hair and bristle arising from a dark brown spot. Between the dorsocentrals these spots are fused into a pair of irregular longitudinal stripes. Scutellum light gray, basal pair of bristles arising from brown spot. Pleuræ dark brown above, pale yellow below. Legs pale yellow, tips of femora and bases of tibiæ brown. Apical and preapical bristles on first two pairs of tibiæ, preapicals on third.

Abdomen yellow; each segment with a dark brown cross band, which is broadly broken in the median dorsal line.

Wings clear; veins pale brown, with dark brown spots at tip of first section of costa and at junction of first and second veins. Costal index about 2.6, fourth vein index about 2.0, 5x index about 1.2, 4c index about 1.1.

Length of body 2½mm., wings 2½mm.

Type and paratypes, from pineapple, sent from Guantanamo, Cuba, by Mr. Chas. T. Ramsden, Dec. 1913. The type itself was bred, from this stock, in New York City, Feb., 1914.

The males agree with the above description in all respects.

This species resembles *D. repleta* Woll., but is easily separated from it on the basis of its banded legs, lighter color, and more slender form.

D. ramsdeni is the "Species A" of Metz (1914, Journ. Exper. Zool. 17, p. 50).

Drosophila saltans, n. sp.

♂. Arista with 5 branches above and 3 below. Antennæ brown, third joint darker. Front over one-third width of head, wider above; reddish brown, triangle and orbits grayish pollinose, with a brown spot above upper orbital bristle. Second orbital one-fifth other two. Second oral bristle nearly as long as first. Carina high and narrow. Face brown, proboscis brownish. Cheeks yellowish brown, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes with short sparse dark pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax grayish brown pollinose, with markings of dark dull brown as follows: a pair of short longitudinal stripes on the front margin, just within the dorso-central row of hairs; two pairs of spots just outside the dorso-central row, one just behind the humeri and the other just behind the transverse suture. Scutellum grayish brown pollinose. Pleuræ dark brown, grayish at the sutures. Legs pale brown, femora and tibiæ darker in the middle. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, each segment grayish pollinose anteriorly.

Wings with a small blackish speck at tip of first vein. Costal index about 2.0; 4th vein index about 2.6; 5x index about 1.7; 4c index about 1.4. Length of body 1½mm., wings 1¾mm.

Type and ten paratypes, from stock bred in New York City, from a pineapple sent from Guantanamo, Cuba, by Mr. Chas. T. Ramsden. Four specimens from Panama, R. P., differ only in that the dorsum of the thorax is lighter, and may be referred to this species.

The name *saltans* is given because the larvæ (like those of *D. cardini*, n. sp.), have the habit of "skipping" as do those of *Piophila casei* Linn. and by the same mechanism.

The species may be recognized by its thoracic pattern, small size and 6 acrostichal rows.

Drosophila earlei, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint dark. Front over one-third width of head, wider above; opaque reddish brown, orbits and triangle grayish pollinose. Second orbital one-third other two. Second oral bristle nearly as long as first. Carina high and narrow; face brown. Cheeks yellowish brown; their greatest width about one-sixth greatest diameter of eyes.

Acrostichal hairs somewhat irregular, in six to eight rows; no prescutellars. Dorsum of thorax coffee brown, with yellow-brown markings as follows: a narrow median longitudinal streak, a pair of stripes including the dorsocentrals and broader anteriorly with external branches behind, a spot on each humerus. Scutellum coffee brown, with yellowish lateral edges. Pleuræ coffee-brown; legs pale brown. First and second tibiæ with apical and preapical bristles, third with preapicals.

Abdomen black, four basal segments, each with an interrupted yellowish anterior band.

Wings clear, veins brown. Costal index about 2.0; 4th vein index about 1.7; 5x index about 1.3; 4c index about 0.9.

Length of body 1¾mm., wings 2mm.

Type and two paratypes, Herradura, Cuba, January 28, 1915 (C. W. Metz). Other specimens are before me from Cristo, Cuba, and Panama, R. P. The females agree with the description given above. This species is named after Prof. F. S. Earle, on whose plantation the type material was collected.

This species will be most easily confused with *D. saltans* n. sp. It differs in its larger size, yellow markings on abdomen, thoracic pattern, and smaller 4th vein index.

Drosophila sulcata, n. sp.

♂. Arista with five branches above and two below. Antennæ reddish brown, third joint dark. Front over one-third width of head, reddish brown, with a dark brown ocellar dot. Second orbital about one-fourth other two. Second oral bristle not quite one-half first. Three large bristles on each palpus. Carina prominent, not very broad, distinctly sulcate. Face reddish brown. Cheeks reddish brown; their greatest width about one-fifth greatest diameter of eyes. Eyes with rather short sparse pile.

Acrostichal hairs in six rows; no prescutellar bristles. Dorsum of thorax grayish pollinose, with somewhat indefinite and variable reddish brown interrupted stripes. Scutellum grayish pollinose. Pleuræ grayish pollinose, reddish brown below. Legs, including coxæ, pale reddish brown. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen grayish, with a dark brown fascia on each side of each segment, leaving usually only a median dorsal and a posterior gray line.

Wings slightly yellowish, veins brown. Costal index about 4.6; 4th vein index about 1.3; 5x index about 0.9; 4c index about 0.7.

Length of body 3mm., wings 3¼mm.

Type and 8 paratypes collected at Cabin John Bridge, Md., April 1914, (3 at sap), by R. C. Shannon (U. S. N. M.). Other specimens have been examined as follows: Dead Run, Fairfax County, and Glencarlyn, Va.; Linnieville, Md.; D. C.; Ottawa, Can.; Pottstown, North Mt., Pa.; Chester, Mass.; Franconia, Hanover, and Bretton Woods, N. H.; Ga.

The females agree with the above description, but the thoracic color is variable in both sexes and is easily obscured in imperfect specimens.

The clearly sulcate carina, large size, six acrostichal rows, and grayish thorax will serve to distinguish this species from any others known to me.

Drosophila virilis, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint dark opaque reddish brown. Front over one-third width of head, wider above; dull coffee brown, ocellar dot black. Second orbital one-third size of other two. Second oral bristle three quarters length of first. Only one long bristle on each palpus. Carina broad, slightly sulcate, nose-like. Face somewhat shiny brown. Width of cheek over one-fourth greatest diameter of eye. Cheeks yellowish brown.

Six acrostichal rows; no prescutellars. Dorsum of thorax and scutellum dark dull brown. Pleuræ and abdomen dull brown, somewhat darker. Legs brown, paler than thorax; no combs on first tarsal joints; preapicals on all tibiæ, apicals on the first two pairs.

Wings clear, veins brown. Costal index about 3.0, 4th vein index about 1.8, 5x index about 1.2, 4c index about 0.9.

Length body 2¾mm., wings 3mm.

Type, allotype and gonotypes from New York, N. Y. The type and allotype were bred from a pineapple exposed at Columbia University; they and their descendants are the only specimens of the species that I have seen. The females agree with the above description.

This is the "species B" of Metz (1914 Journ. Exper. Zool. 17, p. 50; 1915. Am. Nat. 49, p. 187). It is a fruit eating form, and has been kept in the laboratory more than two years, banana being used for food.

The species resembles *D. robusta* n. sp. and *D. melanica* n. sp. rather closely. The six acrostichal rows will separate it from most specimens of *D. robusta;* and from both these species it may be distinguished by its broad cheeks and relatively long second oral bristle.

Drosophila robusta, n. sp.

♂. Arista with six branches above and three below. Antennæ dark brown, second joint pollinose distally. Front over one-third width of head; dark coffee brown, orbits and triangle slightly grayish pollinose. Second orbital fine, about one-fourth length of other two. Second oral bristle not quite one-half size of vibrissa. More than one prominent bristle on each palpus. Carina broad, very slightly sulcate. Face somewhat shining, brown. Cheeks brown, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes with short black pile.

Acrostichal hairs somewhat irregular, in six to eight rows; no prescutellar bristles. Dorsum of thorax dark dull brown, with four faint pollinose longitudinal stripes. Scutellum and pleuræ dark dull brown. Legs pale brown; fore coxæ blackish brown beneath, with a whitish pollinose spot between them. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen grayish brown, each segment with a very broad dark brown fascia on each side; these fasciæ often nearly or quite meet in the middorsal line.

Wings clear; veins brown, subterminal part of first vein very dark. Costal index about 4.0, 4th vein index about 1.6, 5x index about 1.2, 4c index about 0.7.

Length body 2½mm., wings 2¾mm.

Type, allotype and numerous gonotypes, bred in New York, N. Y., from stock obtained at Kushla, Alabama. I have examined specimens of this species from Woods Hole, Mass., Cold Spring Harbor, Long Island, and Ithaca, N. Y., Cabin John Bridge, Md., Falls Church, Va. and Helena, Ark.

The females agree with the description given above; but both sexes vary somewhat in the color of the thorax, and many specimens have the posterior cross-vein distinctly clouded.

Drosophila robusta is a fruit eating form, living on banana in the laboratory. I have specimens bred from potato in Massachusetts.

This species resembles *D. virilis*, n. sp. and *D. melanica*, n. sp. Its oral and palpal bristles and narrow cheeks will separate it from the former. It differs from *D. melanica* in its larger size, black fore coxæ, and darker abdomen.

Drosophila melanica, n. sp.

♂. Arista with four branches above and two below. Antennæ dark brown, second joint grayish above. Front over one-third width of head, wider above; blackish, velvety, orbits and narrow triangle brown. Second orbital about one-third size of other two. Second oral bristle less than one-fourth vibrissa. Carina broad, slightly sulcate. Face blackish brown, dull. Several prominent palpal bristles. Cheeks brown; their greatest width about one-sixth greatest diameter of eyes. Eyes with short thick black pile.

Acrostichal hairs long, in six rows; no prescutellar bristles. Dorsum of thorax dull blackish brown, a small indistinct pair of brown spots on anterior margin, just inside of dorsocentral lines. Humeri grayish brown. Scutellum and pleuræ dark dull blackish brown. Legs, including coxæ, pale brown. Apicals and preapicals on first and second tibiæ, preapicals on third.

Abdomen yellow, with a pair of lateral dark brown fasciæ on each segment.

Wings clear, veins brown. Costal index about 3.8; 4th vein index about 1.4; 5x index about 1.0; 4c index about 0.8.

Length of body 2mm., wings 2¼mm.

Type, allotype and numerous gonotypes, bred at New York, N. Y., from stock collected at Kushla, Alabama, April, 1915. I have examined specimens from Woods Hole and Plymouth, Mass.; Macon, Ga.; St. Louis, Mo.; Kingston, R. I.; Plummer's Island and vicinity, Md.; Dead Run, Va.; North Carolina; Mt. Washington, N. H.; Helena, Ark.

Typical females agree with the above description. Some specimens of both sexes, especially the northern ones, are somewhat lighter in color; but this is perhaps an accidental age difference.

The species resembles *D. virilis*, n. sp., *D. robusta*, n. sp., and *D. affinis*, n. sp. The narrow cheeks and small second oral bristles distinguish it from *D. virilis;* the small size, brown fore coxæ and yellow markings on abdomen from *D. robusta;* absence of combs on male tarsi, broad carina and darker thorax from *D. affinis*. The features that distinguish *D. melanica* from *D. melanissima*, n. sp. and *D. pseudomelanica*, n. sp. are discussed under those species.

D. melanica is the "species C" of Metz. (1914, Journ. Exper. Zool. 17, p. 52).

Drosophila melanissima, n. sp.

♂. Arista with four branches above and two below. Antennæ velvety black. Front about one-half width of head, wider above; blackish brown, velvety. Second orbital about one-third other two. Second oral bristle less than one-fourth vibrissa. Carina broad, slightly sulcate below. Face black. Several prominent palpal bristles. Cheeks brownish black; their greatest width about one-third greatest diameter of eyes. Eyes with short thick black pile.

Acrostichal hairs long, in six rows; no prescutellars. Dorsum of thorax, scutellum and pleuræ brownish black; there is a faint grayish pollinose line extending from the base of the fore coxa to the base of the halter. Legs blackish brown; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark blackish brown, slightly polished.

Wings slightly brownish, veins brown. Costal index about 4.0; 4th vein index about 1.7; 5x index about 1.1; 4c index about 0.7.

Length of body 2mm., wings 2¼mm.

Type collected at Kushla, Alabama, June 22, 1914. In the U. S. National Museum are specimens from Biscayne Bay, Florida, Georgia, and North Carolina. The females among these agree with the above description.

This species is very similar to *D. melanica*, n. sp., and might be considered a color variety of it but for the smaller eyes, broader cheeks and larger oral opening. In color it is decidedly darker than *D. melanica*.

Drosophila pseudomelanica, n. sp.

♂. Arista with five branches above and three below. Antennæ brown. Front about one-third width of head, wider above; brownish red. Second orbital scarcely more than a hair. Second oral bristle two-thirds size of first. Carina flat, rather narrow. Face narrow, brown. Palpi brown, with several prominent bristles. Cheeks brown; their greatest width about one sixth greatest diameter of eyes. Eyes with short pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax and scutellum dull blackish brown; pleuræ brown. Legs pale yellowish brown; apical and preapical bristles on first and second tibiæ, only preapicals on third.

Abdomen shining dark brown, basal segments with lighter median dorsal and anterior lines.

Wings clear, veins brown. Costal index about 4.0; 4th vein index about 1.8; 5x index about 1.3; 4c index about 0.7.

Length of body 1½mm., wings 1¾mm.

Type and two paratypes. Dead Run, Fairfax County, Va., April, 1914 (R. C. Shannon). One specimen, Cabin John Bridge, Md., March, 1914. (Shannon).

This species may be distinguished from *D. melanica*, n. sp. and the other members of its group by the two large oral bristles, narrow face and front and small size.

Drosophila affinis, n. sp.

♂. Arista with five branches above and two below. Antennæ brown, third joint nearly black. Front nearly one-half width of head, wider above; dark brown, lighter below, orbits and triangle pollinose. Second orbital three-fourths third, which is three-fourths first. Carina low, very narrow above; face dull brown. Second oral bristle scarcely one-fifth first. Cheeks grayish brown, their greatest width about one-sixth height of eyes. Eyes with short pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax, scutellum, and pleuræ coffee brown. Legs pale brownish yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third. A comb-like row of black bristles on the inner anterior surface of the first tarsal joint of each front leg, as in the male of *D. melanogaster* Meig.

Abdomen very dark brown, lighter toward the base.

Wings clear. Costal index about 3.6; 4th vein index about 2.6; 5x index about 2.0; 4c index about 1.2.

Length body 2mm., wings 2¼mm.

Type bred from banana, Kushla, Alabama, April 25, 1915. Twelve paratypes, Kushla, Alabama. The females agree with the above description, except that they have no combs on the first tarsi. I have examined numerous specimens from the United States, the following states being represented: Massachusetts, New York, New Jersey, Indiana, Alabama, Texas, Illinois, Pennsylvania, Missouri, Oklahoma, New Hampshire, District of Columbia, Maryland, Georgia, North Carolina and Virginia.

The species may be separated from *D. melanogaster* Meig. on the basis of its color and its six acrostichal rows (*D. melanogaster* has eight). *D. obscura* Fall. also has eight rows and has combs on the second tarsal joints of the front legs of the male, as well as on the first. The females may be confused with *D. melanica*, n. sp., but the narrow carina will serve to identify them as *D. affinis*. Most of the material that has passed as *D. confusa* Staeg. in this country belongs to *D. affinis*.

Drosophila caribea, n. sp.

♂. Arista with five branches above and three below. Antennæ yellow, third joint brownish. Front nearly one-half width of head, wider above; reddish yellow. Second orbital about one-third other two. First oral bristle one and one-half times second. Carina rather broad, flat. Face, cheeks and proboscis yellow. Greatest width of cheeks less than one-sixth greatest diameter of eyes. Eyes thickly set with short yellow pile.

Acrostichal hairs in eight rows; no prescutellar bristles, although there is a transverse row of about four slightly enlarged hairs between the posterior pair of dorsocentrals. Dorsum of thorax, scutellum and pleuræ dull reddish yellow. Legs pale yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen brownish yellow, each segment with an indistinct dark brown posterior margin.

Wings clear. Costal index about 1.5; 4th vein index about 2.4; 5x index about 2.0; 4c index about 1.6.

Length body about 2mm., wings 2¼mm.

Type and eleven paratypes, Havana, Cuba, 1915. Other specimens have been examined from Santiago de Cuba, Santiago de las Vegas, Guantanamo, Herradura, Baracoa, Cuba; Sanchez, R. Dom.; Mayaguez, P. R.; Antigua; Roseau, Dominica; Manaos, Brazil; Panama, R. P.; San Jose, Costa Rica; Punta Gorda, Br. Honduras. This form is quite common in Cuba and Central America, about fruit, on which it breeds. It is also attracted to excrement.

The species is similar to *Drosophila melanogaster* Meig., but it may be recognized by the absence of tarsal combs in the male, paler abdomen, and higher costal and 4c indices. From *D. willistoni* nom. nov. it may be distinguished by the eight acrostichal rows (*D. willistoni* has only six), duller color and stouter shape.

Drosophila orbitalis, n. sp.

♂. Arista with five branches above and three below. Antennæ yellow. Front slightly over one-third width of head, wider above; yellow brown, orbits grayish. Orbitals, as well as other frontal bristles, small; second nearly as large as other two, situated half way between them. Carina prominent, narrow, not sulcate. Face grayish yellow. Only one prominent oral bristle. Cheeks yellow, their greatest width about one-eighth greatest diameter of eyes. Eyes clothed with short pale pile.

Acrostichal hairs in eight rows; no prescutellars. Dorsum of thorax and scutellum polished reddish yellow. Pleuræ and legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen black; terminal segments yellow brown on anterior outer corners.

Wings clear; costal index about 2.6; 4th vein index about 1.3; 5x index about 1.0; 4c index about 0.8. Third and fourth veins slightly convergent.

Length body 2mm., wings 2¼mm.

Type and paratype, Taboga Island, Panama, July, 1907. (Aug. Busck). U. S. Nat. Museum Collection.

The short, subequal, widely separated orbitals will distinguish this species from *D. melanogaster* Meig. and *D. caribea* n. sp., which resemble it rather closely.

Drosophila cardini, n. sp.

♂. Arista with five branches above and two below. Antennæ yellow, third joint brown. Front over one-third width of head, wider above; reddish yellow, orbits grayish. Second orbital about one-fifth other two. Carina broad and flat. Face brownish yellow, somewhat polished. Two prominent oral bristles, nearly equal. Cheeks yellow, their greatest width about one-fifth the greatest diameter of the eyes. Eyes clothed with short pale pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax, scutellum and pleuræ shining reddish brown. Legs yellow; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen shining black; three basal segments with anterior bands of reddish brown, which do not reach the lateral margin.

Wings with small brownish clouds on each cross vein. Costal index about 3.9; 4th vein index about 1.7; 5x index about 1.0; 4c index about 0.9.

Length body 2½mm., wings 2½mm.

Type and twenty paratypes, Havana, Cuba, 1915. Specimens are before me from Santiago de las Vegas, Aguada Pasajeros, Herradura, Cristo, Cuba; Sanchez, R. Dom.; Mayaguez, Arecibo, Jayuya, Adjuntas, P. R.; Dominica, W. I.; San Jose, Port Limon, Costa Rica; Panama, R. P.; Miami, Fla. The species is named for Sr. Patricio Cardin, of the Estacion Agronomico, Santiago de las Vegas, Cuba, through whose kindness Dr. C. W. Metz and I were enabled to collect some of the material of this and other species.

This species is quite variable in color, especially in the female sex. Many specimens are quite pale, and have little black on the abdomen. Dr. C. W. Metz and I have bred several stocks through many generations and have found these variations not to be inherited. They are, however, likely to cause confusion, since these pale females are practically indistinguishable from females of *D. similis* Willist. These two forms are quite distinct, as breeding experiments have shown, and we have been unable to cross them, but it is safest not to identify females as *D. similis* unless they have been bred, or the males are known.

Ordinarily the peculiar shining reddish brown thorax and shining black markings on the abdomen, together with the clouded cross veins, will serve to distinguish *D. cardini*.

I have found this species very common about fruit, on which it breeds, in Cuba and Central America. It is not at all rare in southern Florida.

Drosophila melanderi, n. sp.

♀. Arista with five short branches above and one below. Antennæ yellow, third joint red-brown. Front nearly one-half width of head, reddish yellow, triangle brown. Second orbital about one-fifth other two. One bristle and numerous hairs on oral margin. Carina low, flat and narrow. Face yellow. Cheeks yellow; their greatest width about one-fourth greatest diameter of eyes. Eyes with fine pale pile.

Acrostichal hairs in six rows; no prescutellars. Dorsum of thorax and scutellum somewhat shining reddish yellow. Pleuræ reddish yellow. Legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dull yellow, each of first four segments with an interrupted posterior dark brown band.

Wings clear, veins brown. Costal index about 3.0; 4th vein index about 1.3; 5x index about 1.1; 4c index about 0.7.

Length body 2½mm., wings 3mm.

Type and one paratype, Tacoma, Washington, August 27, 1911 (A. L. Melander). One specimen, Mt. Constitution, Washington. The type is in Professor Melander's collection.

This species resembles the European *D. fenestrarum* Fall., but the acrostichal rows and abdominal pattern are sufficient to show that it is different. Among our American species it will be most readily confused with *D. transversa* Fall. and similar species. The clear wings, single oral bristle, short aristal branches and slender body and wings will serve to identify it.

Drosophila modesta, n. sp.

♂. Arista with about six branches above and three below. Antennæ pale brown, third joint dark. Front over one-third width of head, wider above; opaque yellow. Second orbital about one-fifth other two. Second oral bristle nearly as long as first. Carina broad, flat; face brownish yellow. Cheeks yellow; their greatest width scarcely equal to one-sixth greatest diameter of eyes. Eyes with yellow pile.

Six rows of acrostichal hairs; no prescutellar bristles. Dorsum of thorax dark dull yellowish brown. Pleuræ and legs pale yellowish brown. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen shining yellow; an interrupted dark brown band on the posterior margin of each of the first four segments, and a median anterior dark brown spot on the third, fourth and fifth segments.

Wings with faint clouds on each cross vein and at the tips of second and third veins; veins dark brown. Costal index about 4.3; 4th vein index about 1.7; 5x index about 1.3; 4c index about 0.7.

Length body 2½mm., wings 2¾mm.

Type, allotype and gonotypes bred in New York, N. Y., from stock collected at Kushla, Alabama, April, 1915. I have also examined specimens from New Orleans, La.; Richmond, Arlington, Rosslyn, Dead Run, Va.; Plummer's Island, Md.; Bloomington, Ind.; New York, N. Y. The last specimens were bred from cabbage in November, and I am inclined to suspect were imported with the cabbage. I have also bred the species from banana, grape sap, agaric, and watermelon. The females agree in all respects with the description given above.

This species is similar to *D. tripunctata* Lw., but differs in its abdominal markings, and also in having six acrostichal rows, for *D. tripunctata* has eight. From *D. putrida* n. sp. it is easily separated by the absence of presutural acrostichal bristles; and from *D. transversa* Fall., by its two large oral bristles. The abdominal pattern and dull thorax will distinguish it from *D. quinaria* Lw.

Drosophila putrida, n. sp.

♂. Arista with five or six branches above and two below. Antennæ yellow brown, third joint dark reddish brown. Front nearly one-third width of head, wider above; yellow brown, dull; ocellar dot darker. Second orbital minute. Second oral bristle nearly as long as first. Carina low, rather broad, flat; face yellow brown, somewhat shiny. Cheeks yellow, about one-eighth as wide as greatest diameter of eyes. Eyes with fine light yellow pile.

Six acrostichal rows; no prescutellar bristles; a pair of presutural bristles in the acrostichal rows next to the outer ones. Dorsum of thorax and scutellum shining yellow. Pleuræ and legs pale yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen pale yellow, each segment with a brown band on posterior margin, interrupted in the median dorsal line.

Wings clear. Costal index about 2.8; 4th vein index about 1.6; 5x index about 1.2; 4c index about 0.8.

Length body 2mm., wings 2mm.

Type and paratypes, Woods Hole, Mass. Specimens examined from Vermont, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Illinois, Virginia, North Carolina, Georgia, Alabama and Mississippi. The female agrees with the above description. The species is very common on fungi, in which it breeds.

Easily distinguished from all other members of the genus known to me by the presence of the presutural acrostichal pair of bristles. Some specimens are more brownish than the type.

Drosophila floræ, n. sp.

♂. Arista with four branches above and three below. Antennæ dull brown, third joint darker. Front about one-third width of head, wider above; dull yellowish brown. Second orbital one-half other two. Second oral bristle about one-third first. Carina broad, flat; face dull yellow brown. Cheeks yellow; their greatest width about one-eighth greatest diameter of eyes. Eyes with fine black pile.

Eight acrostichal rows; prescutellars well developed. Dorsum of thorax, scutellum and pleuræ dull brown. Legs pale brown; apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, basal segment with a yellowish brown transverse band.

Wings clear; costal index about 2.5; 4th vein index about 1.8; 5x index about 1.4; 4c index about 1.0.

Length body 2¼mm., wings 2½mm.

Type and paratypes, Havana, Cuba, January and February, 1915. Specimens have been examined from Guareiras, Cuba;

Naguabo, Porto Rico; San Jose, Costa Rica. The females agree in all respects with the above description. The species is usually found in flowers of Datura, melons, etc. on the decaying petals of which it breeds.

The well developed prescutellar bristles, clear wings and dull brown color will be sufficient to distinguish this species from any others known to me.

Drosophila lutzii, n. sp.

♂. Arista with four short branches above and two below. Antennæ yellow brown. Front over one-third width of head, wider above; opaque dark brown, orbits and triangle polished. Second orbital about one-fourth other two. Only one large oral bristle. Carina rather broad, flat, edges sharply angled; face brown. Cheeks brown, their greatest width about one-fifth height of eyes. Eyes with short sparse pile.

Six rows of acrostichal hairs; no prescutellar bristles. Dorsum of thorax, scutellum and pleuræ dark reddish brown, somewhat polished. Legs pale yellowish brown, femora somewhat darker. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen yellowish brown, lighter towards tip.

Wings clear, veins yellowish. Costal index about 2.1; 4th vein index about 1.7; 5x index about 1.3; 4c index about 1.1.

Length body 1¾mm., wings 1½mm.

Type and four paratypes (♂ and ♀), collected at Havana, Cuba, January, February, 1915. The species is very common in many parts of tropical America. I have examined specimens from Guane, Cristo, Havana, Aguada Pasajeros, Guareiras and Guantanamo, Cuba; Hope Gardens, Jamaica; Naguabo, Mayaguez and Adjuntas, Porto Rico; Port Limon, Costa Rica; Biscayne Bay, Key West, and Miami, Florida. It is found in flowers, especially those of Datura, and breeds on the decaying petals. The female agrees with the above description of the male.

The species will be easily known by its small size, shining reddish brown color and short bristles.

Drosophila prognatha, n. sp.

♂. Arista with six branches above and two below. Antennæ yellow, third joint very long and covered with yellow hairs. Front over one-third width of head, dull yellow, ocellar dot brown. Second orbital one-fourth other two. Vibrissæ long, other oral bristles short. Proboscis prominent and projecting forward; carina short, low, narrow and confined to upper part of face. Face dull yellow. Width of cheeks about one-sixth greatest diameter of eyes. Cheeks yellow, a brown spot on each side, just above and behind vibrissa. Eyes with yellow pile.

Six acrostichal rows; no prescutellars. Dorsum of thorax dull reddish yellow, with a pair of darker indistinct longitudinal stripes and dark areas on and behind the humeri. Scutellum reddish yellow. Pleuræ pale yellow, a reddish line running forward from base of wing; darker above this line. Legs pale yellow. Preapical bristles only on third tibiæ, apicals only on second.

Abdomen dull reddish yellow, with posterior black bands on first four segments.

Wings clear. Costal index about 1.9; 4th vein index about 2.0; 5x index about 1.8; 4c index about 1.4.

Length body 2mm., wings 2mm.

Type and ten paratypes, Adjuntas, P. R., June 8-13, 1915 (Lutz and Mutchler). Two specimens, San Francisco Mts., San Domingo, (Busck). The females agree with the above description. Some specimens are a little smaller and have the dark marks on front, thorax and abdomen practically invisible. There are intermediate specimens, and I suppose that the difference is due to age.

The species is distinct from other described species in the color of the thorax. Its most unusual peculiarity is the fewness of the apical and preapical bristles, in which it resembles *D. quadrata* n. sp. The large hairy third antennal joint is also noteworthy.

Drosophila quadrata, n. sp.

♂. Arista with six branches above and three below. Antennæ brown. Front one-half width of head, wider above; pale yellow. Second orbital not distinguishable from neighboring hairs. One large vibrissa, other oral bristles reduced practically to hairs. Carina low and narrow, face broad and excavated on each side of it; face yellow. Proboscis yellow, palpi dark brown. Cheeks yellow, their greatest width about one-fifth greatest diameter of eyes. Eyes with yellow pile.

Eight rows of acrostichal hairs; no prescutellars; the anterior dorsocentral bristles are only a little behind the suture. Dorsum of thorax, scutellum, pleuræ and legs dull brownish yellow. There is a dark brown stripe on the pleura extending as a straight band from just under the haltere almost to the neck. Below this stripe the pleura is paler. Apical bristles only on the second tibiæ, preapicals only on the third.

Abdomen yellow, each segment with a dark brown posterior margin.

Wings clear; costal index about 1.0; 4th vein index about 5.5; 5x index about 6.0; 4c index about 5.0.

Length body 1¾mm., wings 2mm.

Type and three paratypes, Kushla, Alabama, April, 1915. Also one specimen, Tifton, Ga., October, 1896. (Coll. A. L. Melander).

This species is most like *D. prognatha*, n. sp. which it resembles in its few tibial bristles, in the presence of the pleural stripe, etc. The third joint of the antennæ is here small and dark, while in *D. prognatha* it is large and yellow; and the extraordinary wing vein indices of *D. quadrata* will serve to distinguish it from most other species of the genus.

Drosophila superba, n. sp.

♀. Arista with eight branches above and four below. Antennæ brown, third joint dark. Front about one-third width of head, wider above; yellow. Second orbital scarcely more than a hair. Only one prominent oral bristle. Carina low and narrow, confined to upper part of face. Face yellow. Cheeks yellow, their greatest width scarcely one-sixth greatest diameter of eyes. Eyes sparsely clothed with very short, fine, pale pile.

Acrostichal hairs is about ten rows; no prescutellars; a single pair of dorsocentrals. Dorsum of thorax yellow, with two pairs of interrupted brownish longitudinal stripes, the median pair broader than the outer. Scutellum brownish yellow; pleuræ yellow, with two longitudinal dark reddish brown stripes. Legs yellow. Apical and preapical bristles on first and second tibiæ, preapicals on third.

Abdomen dark brown, yellow at base.

Wings brownish black, with four hyaline areas; one at the base; one including the apical part of the costal cell and extending to the anal cell; a band extending directly across the wing about its middle, between the two cross veins; a spot reaching from the middle of the first posterior cell to the wing margin in the second posterior cell. Costal index about 3.0; 4th vein index about 1.0; 5x index about 1.0; 4c index about 0.7.

Length body 3mm., wings 3¼mm.

Type, Cacao, Trece Aguas, Alta Vera Paz, Gautemala (Schwarz and Barber). U. S. N. M. collection.

The color of the wings and pleuræ and the single pair of dorsocentrals will serve to distinguish this species.

Drosophila projectans, n. sp.

♂. Arista with five branches above and one below. Antennæ brown. Front one-third width of head, broader above, velvety black, brownish below, with a silvery whitish reflection, small triangle and orbits polished. Second orbital minute. Second oral bristle quite small. Carina high, narrow; face brown. Clypeus prominent. Proboscis and palpi pale yellow. Cheeks yellow, their greatest width about one-sixth the greatest diameter of eyes. Eyes bare.

Dorsum of thorax strongly convex; a single pair of dorso-central bristles and no prescutellars. Acrostichal hairs in six rows. Dorsum of thorax, scutellum, and pleuræ above wings shining blue black. Pleuræ below wings, and legs, pale yellow. Apical bristles on second tibiæ, preapicals on third.

Abdomen shining black. First segment with one median and two small lateral yellow spots; second segment with a median one, third with an anterior yellow band.

Wings black just beyond the base, a black oblique band from the apex of the costal cell to the apex of the anal cell, tip of second vein darkened. The apical portion of the costal cell is drawn out into a rounded process, extending beyond the rest of the anterior margin of the wing. Costal index about 1.1; 4th vein index about 2.2; 5x index about 2.0; 4c index about 1.9.

Length body 1½mm., wings 1½mm.

Type, San Francisco Mts., St. Domingo, 4. 9. 05, (A Busck) U. S. N. M. collection. A headless specimen from Montserrat, Trinidad, W. I. (A. Busck) agrees.

This species belongs to the same group as *D. dimidiata* Lw. and *D. thoracis* Willist. The projecting costal cell, low costal index and spotted wings will serve to distinguish it from those species.

A REVIEW OF THE AMERICAN SPECIES OF XYLOCELIA.

(Hymenoptera; Psenidae.)

By Clarence E. Mickel, Lincoln, Nebraska.

The genus *Xylocelia* has received comparatively little attention from systematists so far as the American species are concerned. Dr. A. S. Packard recognized the genus as represented in our fauna in 1867 under the name *Diodontus* of authors (nec Curtis), and placed in it the new species *americanus*. In 1892 Mr. W. J. Fox described five new species and gave a synoptic key for the six species then known. Since 1892 a number of new species have been described by Messrs. Cockerell and Fox, Mr. H. L. Viereck, Mr. S. A. Rohwer and Dr. E. G. Titus. While working over the material in the collection of the University of Nebraska recently, seven new forms were noted by the writer. With this addition the list of known American forms of *Xylocelia* totals twenty-five and it seems desirable to present at this time a synoptic key for separating the species. In cases where examples of a species have not been at hand, the characters used in the table are based on the original descriptions. No doubt more careful collecting of our smaller wasps will bring other new forms to light, and it is hoped that this review may be of service in determining the described American species. The types of the seven new species here described are in the entomological collection of the University of Nebraska. The writer wishes to acknowledge his indebtedness to Dr. E. G. Titus for the loan of the type of *Xylocelia adamsi*, and to Prof. Myron H. Swenk for going over the manuscript.

Genus *Xylocelia* Rohwer.

1837. *Diodontus*, Shuckard, Essay indig. Fossor. Hymen., p. 186, (nec Curtis).
1867. *Diodontus*, Packard, Proc. Ent. Soc. Phila., vi, p. 392.
1892. *Diodontus*, Fox, Trans. Amer. Ent. Soc., xix, p. 314.
1915. *Xylocelia*, Rohwer, Proc. U. S. Nat. Mus., xxxxix, p. 243.

SYNOPSIS OF THE SPECIES.

FEMALES.

1. Mandibles yellowish or whitish...... 4
   Mandibles entirely black...... 2
2. Mesoscutum with the punctures sparse and indistinct on the posterior half; anterior half of front striato-punctate, the striæ becoming more or less obsolete on the posterior half...... *ater.*
   Mesoscutum with punctures distinct and rather close throughout; front with strong separated punctures...... 3
3. All the tibiæ and tarsi reddish brown, more or less testaceous beneath; nervures of anterior wings yellowish testaceous...... *adamsi*
   All the tibiæ and tarsi black; nervures of anterior wings black...... *nigritus*
4. Posterior lobes of pronotum yellowish...... 8
   Posterior lobes of pronotum entirely black...... 5
5. Posterior face of propodeum with a median, moderately deep, wedge-shaped fovea, the remainder of the posterior face finely, irregularly rugose...... 6
   Posterior face of propodeum without any wedge-shaped fovea, the entire surface coarsely reticulate...... 7
6. Apical antennal joint with a strong longitudinal furrow beneath; all the tibiæ testaceous; emargination of labrum broad and deep...... *antennatus*
   Apical joint of antennæ not furrowed beneath, simple; all the tarsi more or less blackish; emargination of labrum narrow, moderately deep. *metathoracicus*
7. Legs entirely black; head smooth, shining, sparsely punctate...... *americanus*
   Legs more or less testaceous; head not smooth, distinctly punctate; palpi light testaceous; labrum broadly and shallowly emarginate.. *spiniferus*
8. All the tibiæ yellowish or orange red, not black...... 9
   Middle and hind tibiæ more or less blackish; wing nervures blackish...... 10
9. Abdomen shining, with very close, fine punctures; nervures of wings testaceous...... *occidentalis*
   Abdomen shining, impunctate; nervures of wings black...... *florissantensis*
10. Front rather densely punctate; abdomen distinctly petiolate...... *gillettei*
   Front sparsely but distinctly punctate; abdomen not distinctly petiolate, subsessile...... 11
11. Postero-lateral angles of propodeum strongly produced; posterior face of propodeum finely, sparsely rugose, with a rather deep, median, wedge-shaped fovea...... *striatus*
   Postero-lateral angles of propodeum not strongly produced; posterior face of propodeum rather coarsely reticulate...... *siouxensis*

MALES.

1. Mandibles yellowish or whitish...... 7
   Mandibles entirely black...... 2
2. Posterior lobes of pronotum black...... 3
   Posterior lobes of pronotum yellowish; antennal joints 8-12 serrate beneath...... *maestus*
3. Antennal joints not spined beneath...... 4
   Antennal joints 9 or 10-12 slightly spined beneath...... 5
4. Abdomen microscopically punctate, appearing impunctate...... *flavitarsus*
   Abdomen punctured with strong, distinct, separated punctures...... *cockerelli*
5. Mesoscutellum striated posteriorly; antennal joints 9-12 slightly spined beneath...... *argentinæ*
   Mesoscutellum punctured like the mesoscutum; antennal joints 10-12 slightly spined beneath...... 6
6. Cheeks striato-punctate; propodeum indistinctly channeled above.. *vallicolæ*
   Cheeks hardly striated; propodeum not channeled above, subsp. *vallicolæ salicis*

7. Posterior lobes of pronotum black..13
Posterior lobes of pronotum pale or yellowish..............................8
8. Antennal joints 9-12 not serrate beneath.....................................9
Antennal joints 9-12 serrate beneath..10
9. Mesoscutum subopaque, with minute almost adjoining punctures. *brunneicornis*
Mesoscutum shining, sparsely punctured.......................... *fraternus*
10. Clypeus produced in the middle, with two large, obtuse teeth...... *bidentatus*
Clypeus not produced in the middle..11
11. Front subopaque, very densely punctate, appearing granulose..... *occidentalis*
Front more or less shining, with separated or sparse punctures............12
12. Front with distinct, separate punctures; frontal impressed line faint. *neomexicanus*
Front shining, with a few scattered punctures; frontal impressed line very distinct.. *florissantensis*
13. Front sparsely punctured; lineolate running into tessalate; antennæ simple, not serrate beneath................................. *leguminiferus*
Front densely punctured; antennæ more or less serrate beneath............14
14. Distance between the posterior ocelli a little greater than the distance between the lateral ocellus and the nearest eye margin, lateral margin of posterior face of propodeum not toothed..................... *crassicornis*
Distance between the posterior ocelli distinctly less than the distance between the lateral ocellus and the nearest eye margin; lateral margin of posterior face of propodeum toothed............................ *rugosus*

Xylocelia occidentalis Fox.

1892. *Diodontus occidentalis* Fox, Trans. Amer. Ent. Soc., xix, p. 315.

Type locality: Southern California and Arizona. The University collection contains one female and four males from the following Nebraska localities:

Sowbelly Canyon, Sioux County, June 23, 1911 (R. W. Dawson), 1 ♀; Glen, Sioux County, July 12, 1910 (L. Bruner), 2 ♂; Monroe Canyon, Sioux County, August 16, 1912 (R. W. Dawson), 1 ♂; Monroe Canyon, Sioux County, August 20, 1908 (R. W. Dawson), 1 ♂.

Xylocelia rugosus Fox.

1892. *Diodontus rugosus* Fox, Trans. Amer. Ent. Soc., xix, p. 315.

Type locality: Montana, Illinois. Two specimens at hand from Omaha; July 2, 1913 (L. T. Williams), ♂ and August 1, 1914 (L. T. Williams), ♂.

Xylocelia brunneicornis Viereck.

1906. *Diodontus brunneicornis* Viereck, Trans. Amer. Ent. Soc., xxxii, p. 212.

Type locality: Sedgwick County, Kansas.

Xylocelia florissantensis Rohwer.

1909. *Diodontus florissantensis* Rohwer, Trans. Amer. Ent. Soc., xxv, p. 107.

Type locality: Florissant, Colorado.

Xylocelia crassicornis Viereck.

1904. *Diodontus crassicornis* Viereck, Trans. Amer. Ent. Soc., xxx, p. 243.

Type locality: Corvallis, Oregon.

Xylocelia fraternus Rohwer.

1909. *Diodontus fraternus* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 106.

Type locality: Florissant, Colorado.

Xylocelia flavitarsus Fox.

1892. *Diodontus flavitarsus* Fox, Trans. Amer. Ent. Soc., xix, p. 316.

Type locality: Colorado.

Xylocelia leguminiferus Cockerell and Fox.

1897. *Diodontus leguminiferus* Cockerell and Fox, Proc. Acad. Nat. Sci. Phila., p. 141.

Type locality: Sante Fe, New Mexico.

Xylocelia neomexicanus Rohwer.

1909. *Diodontus neomexicanus* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 106.

Type locality: Rowe, New Mexico.

Xylocelia maestus n. sp.

♂. Length 5.5mm. Labrum not exposed; front strongly rugusopunctate; vertex and occiput finely granulate with distinct punctures; genæ with close elongate punctures which give them the appearance of being striato-punctate; impressed line of front wanting; antennal joints 8-12 serrate beneath; antennæ puberulent, joints 1 and 2 of flagellum equal; mesoscutum strongly punctured, densely so anteriorly; mesoscutellum with fine, well separated punctures; episterna anteriorly very coarsely reticulate, posteriorly finely so, tending to become obliquely rugose; propodeum above coarsely reticulate, posterior face with larger reticulations, supra-medially there is a large triangular fovea, much larger than the others on the posterior surface; abdomen distinctly microscopically punctate, the punctures becoming larger on the apical segments; lower portion of front, and clypeus silvery pubescent. Wings hyaline, stigma and nervures of anterior wings piceous. Black; posterior lobes of pronotum yellowish; palpi, tegulæ, all the tibiæ in front, anterior tarsi, and basal half of middle tarsi, testaceous.

♀. Unknown.

Type: A male collected at Omaha, Nebraska, August 29, 1914 (L. T. Williams).

One paratype collected at the same time and place. Most nearly related to *flavitarsus*, from which it differs in having the antennæ serrate beneath, the posterior lobes of the pronotum yellowish, and other minor characters.

Xylocelia argentinæ Rohwer.

1909. *Diodontus argentinæ* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 104.

Type locality: Cripple Creek, Colorado.

Xylocelia vallicolæ Rohwer.

1909. *Diodontus vallicolæ* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 104.

Type locality: Florissant, Colorado.

Xylocelia vallicolæ salicis Rohwer.

1909. *Diodontus vallicolæ salicis* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 105.

Type locality: Boulder, Colorado.

Xylocelia americanus Packard.

1867. *Diodontus americanus* Packard, Proc. Ent. Soc. Phila. vi, p. 393.

Type locality: Brunswick, Maine.

Xylocelia spiniferus n. sp.

♀. Length 4.5-5mm. Labrum broadly and very shallowly emarginate; front finely granulate with distinct punctures; vertex more closely punctured, cheeks sparsely punctured; antennæ puberulent, first joint of flagellum slightly longer than the second; mesoscutum with fine, distinct punctures, the punctures quite dense anteriorly; mesoscutellum shining, microscopically punctate; episterna coarsely reticulate, obliquely rugose posteriorly; propodeum coarsely reticulate above, more openly so on the posterior face; sides of propodeum coarsely rugose; the lateral margins of the propodeum produced, forming a short, blunt spine; abdomen apparently impunctate; wings hyaline; stigma and nervures of anterior wings piceous. Black; mandibles yellowish (except reddish at tips); palpi, tegulæ, anterior tibiæ and tarsi, intermediate tibiæ in front, intermediate tarsi basally, apex of posterior femora and base of posterior tarsi, all light testaceous.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, June 12, 1914 (L. T. Williams); paratypes as follows: Omaha, June 12, 1914 (L. T. Williams), 2 ♀; Omaha, July 19, 1914 (L. T. Williams), 1 ♀; Omaha, July 20, 1914 (L. T. Williams), 2 ♀.

Apparently related to *americanus* from which it differs in having the legs more or less testaceous, the front distinctly and fairly closely punctate, and the tarsal joints not unusually spinose.

Xylocelia antennatus n. sp.

♀. Length 4.5mm. Labrum deeply and roundly emarginate; front finely granulate, distinctly punctate; vertex and occiput similarly sculptured; cheeks sparsely punctate; antennæ short, slightly longer than the head; the last joint with a longitudinal furrow beneath; mesoscutum distinctly punctate, densely so anteriorly; mesoscutellum with small, shallow punctures, slightly impressed medially, episterna anteriorly, quite coarsely reticulate, posteriorly finely rugose; upper portion of the propodeum finely reticulate, grading off into a finely rugose sculpture on the posterior face and the sides; posterior face of propodeum with a median, wedge-shaped, fairly deep fovea; abdomen with fine, well separated punctures; the four apical segments somewhat pubescent; wings hyaline; stigma and nervures of the anterior wings blackish. Black; mandibles yellowish (except the tips reddish); tegulæ and the tibiæ testaceous.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, July 15, 1914 (L. T. Williams).

This species and the following one differ from the other American species of this genus in the fine sculpture of the posterior face of the propodeum and the episterna. They are probably most closely related to *americanus*, from which this species differs most obviously in the above characters and by the furrow of the apical antennal joint beneath.

Xylocelia metathoracicus n. sp.

♀. Length 4.5-5mm. Labrum narrowly and deeply emarginate; front microscopically granulate, with distinct well-separated punctures; frontal impressed line distinct; vertex, occiput and cheeks sculptured like the front; antennæ short, slightly longer than the head, puberulent; first joint of flagellum slightly longer than the second; mesoscutum shining, densely punctate anteriorly, the punctures sparser posteriorly; mesoscutellum slightly impressed medially, rather sparsely punctate; episterna anteriorly somewhat roughly sculptured, slightly reticulate and strongly, deeply punctate, the sculpture tending to become finely rugose posteriorly, upper surface of the propodeum finely reticulate, the posterior face finely rugose, provided with a small, median, wedge-shaped fovea; sides of the propodeum finely granulate; abdomen microscopically, but distinctly punctate; pygidium narrow, about twice as long as broad, rounded at the apex, uniformly punctured; wings hyaline, nervures of anterior wings dark testaceous, stigma black. Black; mandibles except the tips yellowish; tegulæ and anterior tibiæ in front testaceous.

♂. Unknown.

Type: A female taken at Omaha, Nebraska, July 2, 1913 (L. T. Williams). Related to *antennatus*. Differs in having the apical joint of the antennæ simple, the sides of the propodeum more delicately sculptured and only the anterior tibiæ in front testaceous.

Xylocelia gillettei Fox.

1892. *Diodontus gillettei* Fox, Trans. Amer. Ent. Soc., xix, p. 316.

Type locality: Fort Collins, Colorado. One female specimen in the University collection from Harrison, Nebraska, August 20, 1912 (R. W. Dawson).

Xylocelia striatus n. sp.

♀. Length 6-6.5mm. Labrum not exposed; front very finely granulate, sparsely punctate; impressed line of front wanting; antennæ distinctly longer than the head, slightly puberulent; first joint of flagellum distinctly longer than the second; mesoscutum shining, densely punctate anteriorly, very sparsely punctate posteriorly; mesoscutellum shining, with a very few shallow punctures; episterna coarsely, transversely rugose; upper surface of propodeum with a fairly distinct, reticulate inclosed space, laterally with the upper surface obliquely rugose; the posterior face finely rugose, with a median, wedge-shaped fovea; sides of the propodeum sparsely, obliquely striate, the posterolateral angles produced, forming a blunt spine; abdomen finely, distinctly punctate; wings hyaline; stigma and nervures of anterior wings piceous. Black; mandibles except the tips, the posterior lobes of the pronotum yellowish; tegulæ and anterior tibiæ in front yellowish testaceous. Form robust.

♂. Unknown.

Type: A female collected at Dickinson, North Dakota, July 4, 1914 (O. A. Stevens); one paratype collected at Laramie, Wyoming. May easily be distinguished by the coarse sculpture of the episterna, the characteristic sculpture of the posterior face of the propodeum, the presence of blunt lateral spines on the propodeum and the robust form.

Xylocelia siouxensis n. sp.

♀. Length, 5mm. Labrum not exposed; front finely granulate, sparsely punctate; impressed line of front distinct; vertex, occiput and cheeks sculptured like the front; antennæ distinctly longer than the head, slightly puberulent; first joint of flagellum distinctly longer than the second; mesoscutum shining, densely punctate anteriorly, very sparsely punctate on the posterior half; mesoscutellum shining very sparsely punctate; episterna above coarsely reticulate anteriorly, below and posteriorly, finely, transversely rugose; propodeum above finely reticulate, the posterior face more shining, with quite large, shallow foveæ, supra-medially there is a small, somewhat depressed, triangular area; sides of the propodeum rather shining, with four or five coarse, oblique striæ; abdomen microscopically punctate; pygidium about one and one-fourth times as long as wide; strongly punctate; wings hyaline, stigma and nervures of anterior wings piceous. Black;

mandibles, except the tips and posterior lobes of the pronotum yellowish; tegulæ and anterior tibiæ in front testaceous.

♂. Unknown.

Type: A female collected in Monroe Canyon, Sioux County, Nebraska, August 19, 1912 (R. W. Dawson). Related to *striatus*, but is smaller, more slender, has the propodeum sculptured differently and the postero-lateral angles of the propodeum not produced.

Xylocelia nigritus Fox.

1892. *Diodontus nigritus* Fox, Trans. Amer. Ent. Soc., xix, p. 317.

Type locality: Colorado.

Xylocelia adamsi Titus.

1908. *Diodontus adamsi* Titus, Ecology of Isle Royale, Michigan Survey, p. 319.

The following description is drawn from the type specimen kindly loaned the writer by Dr. E. G. Titus.

♀. Length 7.1mm. Labrum deeply and angulately emarginate, the teeth formed by the emargination acute; front with strong, rather close punctures, finely granulate between the punctures; median impressed line of front faint; vertex, occiput and cheeks punctured like the front; (antennæ missing in the type); mesoscutum with strong, rather close punctures, denser on the anterior and posterior margins; suture between the mesoscutum and mesoscutellum foveolate; mesoscutellum distinctly punctured; episterna coarsely reticulate anteriorly, obliquely rugose posteriorly; upper surface of propodeum coarsely reticulate; posterior face of propodeum coarsely reticulate, supramedially with a large, pentagonal enclosed area; sides of propodeum with a few, coarse rugæ; abdomen microscopically punctate; pygidium triangular, about one and one-fourth times as long as wide, strongly punctured on the basal half; wings hyaline, stigma black, nervures yellowish testaceous. Black; tegulæ brown, yellowish anteriorly; all the tibiæ and tarsi reddish brown, more or less testaceous beneath.

♂. Unknown.

Type: A female collected at Isle Royale, Michigan (Adams). Related to *nigritus*, but the sculpture of the propodeum, coloration of anterior wing veins, and of the tibiæ and tarsi, are different.

Xylocelia ater n. sp.

♀. Length 6-7mm. Labrum large, deeply and angulately emarginate; lower portion of front tending to be striato-punctate; upper portion of front fairly closely and shallowly punctate; median impressed line of front very faint; vertex, occiput and cheeks punctured like the front; mesoscutum shining, densely punctured anteriorly, the punctures fine and sparse on the posterior half; mesoscutellum finely and rather closely punctured; episterna coarsely reticulate anteriorly, coarsely obliquely rugose posteriorly; upper surface of propodeum coarsely reticulate; posterior face of propodeum coarsely reticulate, with a large, supra-medial, triangular fovea; sides of propodeum very coarsely obliquely rugose; abdomen rather closely, microscopically punctate; pygidium triangular, about one and one-half times as long as wide, strongly punctured; wings hyaline; stigma and nervures of anterior wings piceous. Entirely black.

♂. Unknown.

Type: A female collected at Omaha, Nebraska, July 27, 1914 (L. T. Williams). Four paratypes as follows: Omaha, June 20, 1914 (L. T. Williams), 1 ♀; Omaha, July 1, 1913 (L. T. Williams), 1 ♀; Omaha, August 29, 1914 (L. T. Williams), 1 ♀; one female specimen without data.

Related to *nigritus*, but differs in the differently sculptured front and propodeum, and the mesoscutum not strongly punctured before the mesoscutellum.

Xylocelia cockerelli Rohwer.

1909. *Diodontus cockerelli* Rohwer, Trans. Amer. Ent. Soc., xxxv, p. 105.

Type locality: Florissant, Colorado.

Xylocelia bidentatus Rohwer.

1911. *Diodontus bidentatus* Rohwer, Proc. U. S. Nat. Mus., xxxx, p. 560.

Type locality: Nerepsis, New Brunswick. This species cannot be the male of *Xylocelia adamsi*, as has been suggested by Rohwer, because of the different structure of the clypeus.

AQUATIC HEMIPTERA. A STUDY IN THE RELATION OF STRUCTURE TO ENVIRONMENT.

By J. R. de la Torre-Bueno, White Plains, N. Y.

Water is everywhere. Wherever there is water, there are to be found Aquatic Hemiptera. From the woodland spring deep in the cool and dusky shadows to the tropic ocean steaming in the flaming rays of the noonday sun, these daring insect navigators adventure themselves on the bosom of the waters, to them as vast as, even vaster than the mighty seas were to the bold mariners of old. Protean in form, variable in size—some less than the head of a pin, others of monster size for insects, for they attain the length of half a foot—these fierce pirates range the waters, seeking prey. Not even the wide-spread and multiform water beetles exhibit such a wide diversity of form, structure and habitat.

The old-time divisions of *Cryptocerata* and *Gymnocerata Littoralia* separate these two Hemipterous groups on the obvious character of the absence or presence of visible, free antennæ, and very fairly divide the dwellers in the waters from those that live upon them or on their shores. And in this antennal diversity we have indeed a character arising strictly from the conditioning environment. Obviously, long antennæ, while of the utmost use to the above-water forms, would be distinctly in the way in deep-swimming insects, so in the Order *Sandaliorrhyncha*, containing the family *Corixidæ*, and in the Heteropterous families *Notonectidæ*, *Naucoridæ*, *Belostomatidæ* and *Nepidæ*, the antennæ are three or four-jointed, concealed in foveæ under the head, the joints being sometimes palmately explanate, as in *Lethocerus;* sometimes stout and simple, with fringing hairs, as in *Notonecta*. But the nymphal development of *Belostoma* and *Ranatra*, for example, points to the simple, stout, three- or four-jointed antenna as the primitive form, since in the early stages of these bugs they are simple and do not begin to show the explanations until the third or fourth instar.

The wings in these groups are misleading phylogenetically, since the venation seemingly is very simple in some instances, and actually so in others. Of course, a sub-aquatic life must profoundly modify the organs of flight if they are unused, so in *Plea* the specialization reaches such a degree that the second pair of wings is absent and the first pair is completely coriaceous and hardened and soldered together, which, in passing, is also the case in the genera *Nerthra* of North America and *Peltopterus* of Africa, in the *Gelastocoridæ*, which are forms living on the banks of streams and bodies of water; and in the *Aphelocheirinæ* of the Old World, certain dimorphic species exhibit wingless forms. In *Ranatra* the cross veins of the second pair of wings are reduced to mere spurs arising from the longitudinal veins, and in the first pair are entirely absent. In *Anisops* and *Buenoa*, *Enithares* and *Nychia*, the entire hemelytra (also called tegmina) are hyaline and with nothing but a few nearly obsolete longitudinal veins, and in the last named, the second pair of wings is absent. All the *Belostomatidæ* are strong fliers, and here, as may be imagined, the wings are large and powerful, the venation of the upper and lower pairs complete, except that in some forms, the membrane of the tegmina is nearly obsolete. The *Naucoridæ* also have unspecialized wings and the *Corixidæ* as well, in the majority of cases. To anyone at all familiar with these groups at first hand, the absurdity of calling them primitive is self-evident. From what has been said, it can readily be seen that the wings in the aquatic forms are unreliable and misleading as criteria of position in the phylogenetic scale. Where they have continued to be of use, the wings persist in a fairly non-complex form; where disuse has ruled, they have been modified and even have become obsolete to the extent of disappearing.

The most profound changes, as might be supposed, have taken place in the respiratory apparatus, which has become adapted in the most remarkable ways to aquatic life; and in the legs which have been transformed to cope with the medium in which the insects move. There are three main forms of respiratory apparatus among the water-dwellers, which may be called the *dorsal reservoir and pile*, the *anal tube*, and the *abdominal channel types*. The tracheal systems as such are practically identical in all three forms of air supply. The *Corixida*, *Belostomatidæ* and *Naucoridæ* have the dorsal reservoir; the *Notonectidæ* the abdominal channel; and the *Nepidæ* the tube type. In the forms with pile and a dorsal reservoir, practically the entire abdomen is pilose and the dorsum more or less concave, forming a reservoir under the convex wings, which is ordinarily filled with air. This air is renewed by absorption from the atmosphere direct and also by reoxygenation from the contained air in the water. In the *Corixidæ*, the abdomen also can be seen covered with a silvery coating of air imprisoned in the pile. The insects of this last group, as a general rule, remain at the bottom, holding fast to pebbles, grains of sand, and other inequalities affording a hold, and from time to time may be seen to pass the third pair of legs through the air coating. Now and again they swiftly ascend, impinge upon the surface-film and dart back to the bottom. The air they carry makes it unnecessary for them to exert themselves to go up, but their descent, while quick, is laborious, and it is this extreme lightness that compels them to anchor themselves, so to speak, in order to remain at the bottom. The *Naucoridæ* haunt the aquatic vegetation among which they creep, and to renovate their stored air, they come to the surface, where the tip of the abdomen breaks through the surface film and the air they carry is purified by diffusion or perhaps by being expelled by body movements, fresh air being then drawn in to replace it. In this family, or group, as in the *Belostomatidæ*, the dorsal part of the abdomen is hollowed out, but only slightly, and is covered with a heavy pile, which affords storage for much air and makes it unnecessary for the bug to come to the surface with any degree of frequency to purify this stored air, which to some degree must be done also by absorption of the oxygen given off by the aquatic vegetation it haunts. In the *Belostomatidæ*, however, there are two more or less retractile strap-like appendages, the lengthened peritreme of the sixth abdominal spiracles, which are moved from the connexivum and open dorsally at a slit in the abdomen, which on the under side is covered in both sexes by the genital plate. These strap-like appendages have been employed as specific characters, based on their comparative lengths, but as they are, as already stated, more or less retractile, individuals of the same species, *L. americanus* for instance, will have them of different lengths. They have also been considered to be a part of the genital apparatus and perhaps to be ovipositors, but a simple dissection suffices to show anyone who will take the pains to make it, that they are strictly respiratory appendages, which may be readily observed in operation in aquaria. These appendages break through the surface film and the hollowed sides being placed in juxtaposition, they form a tube leading air to the spiracles, as already mentioned. These spiracles are larger than the others, and from them lead the two main tracheal tubes lengthways of the body, which connect by side branches with each other and with the functional abdominal spiracles. These spiracles are placed in a pilose stripe, silvery with enmeshed air when the bug is in water, situated on the under side of the abdomen at the connexivum. The thoracic spiracles are also large and functional, but from their structure, size and position are evidently used for respiration only when the bug is in flight. The nymphal respiratory adaptation is quite different, as the strap-like appendages are absent, the abdomen is totally covered with a long and thick pile, and there are two large spiracles situated under the sternal plates, which are very large and fringed with long hairs.

The typical, and only, representatives of the anal tube type of aquatic respiration are the *Nepidæ*. This family is extremely peculiar, and its aquatic life offers no criterion to its phylogenetic position. Based on certain structural characters, it has been removed from the Pagiopod Heteroptera to the Trochalopod series by Schjödte, followed by Kirkaldy. This has not been accepted by the European master, O. M. Reuter, but the manner of oviposition, and therefore, the genital characteristics, have been overlooked. These, if at all valid as indications of affinity, confirm the propriety of its removal to the vicinity of the *Reduviidæ*, to certain of which it has indeed a striking superficial resemblance in structure, which is borne out by the appendages of the ovum and by the egg-laying habits, a parallel to which is to be found in *Melanolestes abdominalis*. This predaceous Reduviid, not unfrequently found under stones in fields, inserts its eggs into the earth, leaving at the surface a crown of filaments, which are greater in number but similar in appearance to the seven filaments surmounting the ovum of *Nepa*. For this reason, it seems best to continue to consider this family as properly placed in the Trochalopoda and near to the *Reduviidæ*, as has been done by Kirkaldy.

Reverting now to the respiratory tube in this family of water-bugs, this, as is well-known, consists of two parts fringed with hairs, and grooved in the inner surface, forming thus two half tubes longitudinally divided. When the insect is submerged these two half tubes are kept together by the pressure of the water, the hairs serving to prevent leakage of air at the junction or seam between the two halves of the tube. These two halves are nothing but the lengthened peritreme of the seventh pair of abdominal spiracles, and they vary in length with the genus and species and even with the individual. It has been experimentally demonstrated that the shortening of the tube in any individual in no wise interferes with its respiration. But what does not appear to be so well known, if known at all, is that the halves may be of unequal length without at all affecting the usefulness of the tube. I have observed this in a specimen of *Ranatra* thus maimed, which was kept alive in an aquarium for a considerable period and which suffered no inconvenience from the inequality of the halves of the air tube. As the bug hangs head down from the water plants, the apex of the tube pierces the surface film and leads air in to the round spiracles situated at the base of each filament, from which arise the two main longitudinal tracheal trunks. In *Nepa*, the tube is short, as it is in *Cercotmetus*, a near relative to *Ranatra*, and in *Curicta*, the form that bridges the gap between *Ranatra* and its allies and the *Nepa*-like forms; on the other hand, in *Ranatra* it is long (with perhaps one or two exceptions), as well as in *Laccotrephes* and other exotic genera. Here is a distinct adaptation to a preferred habitat, as *Ranatra* and the other long-tubed genera are deep-water dwellers, while *Nepa* and its short-tubed congeners is to be found in shallows among grasses. In the *Nepidæ* as a whole there is a most peculiar respiratory structure—the so-called false spiracles, which are six in number and are situated in the connexivum at the third, fourth and fifth abdominal segments. These false spiracles are large and oval in outline, and quite visible to the naked eye. Under the magnifier they are seen to consist of an opaque plate set in a raised margin and provided with round perforations which, in turn, are occluded by a diaphanous membrane. The true spiracles in these segments of the abdomen, as well as in the second segment, are nonfunctional, the former being set in the widened peritreme of these colander-like openings. No experimental evidence is yet at hand to definitely indicate the purpose of these peculiar structures, but in view of the absence of storage reservoirs for air and of the bug's proneness to submerge itself for long periods of time, it is not unreasonable to surmise that dissolved air is extracted from the water, thus aerating the body fluids as they flow by within the body cavity. The other functional spiracles are the thoracic, which are large and well-developed and apparently used when the insect is in flight, as they are exposed by bending the thorax forward when *Ranatra*, for instance, takes to the air. In the nymph, the respiratory device is superficially the same as in the adult, but is actually quite different. Here all the abdominal spiracles are functional and air is led to them by a very short tube. This is formed by the folding over of the produced last abdominal segment, the amplified connexivum of the others being bent over to form a channel over the spiracles, which are thus in direct contact with air. The internal organization of the respiratory system in nymphs has not as yet been investigated.

The third type of respiratory devices, that is, the abdominal channel, has been but little studied. It is, however, extremely simple. The abdomen is keeled down the middle and from this keel spring outwardly toward the sides of the body elastic and fairly stiff and close-growing long hairs, which meet similar hairs arising from the connexivum edge. There is thus formed a channel on each side of the abdomen which is filled with air and in which the spiracles are placed. The bugs hang in the water abdomen up with its extremity just piercing the surface film. In most species there are three tufts of hair which spread out on the surface leaving an open, water-free spot in the middle which is the point where the connection is made between the abdominal reservoirs and the atmosphere. When totally submerged, the opening closes in some way not well explained so far, although the writer believes that the three tufts mentioned lap over and in some manner serve to obstruct the entrance of water into the channels. In any case, these channels act as storage reservoirs while the insect is in its element. The hairs are not set so near together as to touch, but they are sufficiently close to form an aqueous film at a tension between them which acts to retain the air in the chambers and at the same time to keep water out. This is very necessary in many species, as they only come to the surface to renovate their air supply, remaining at some distance below the surface the greater part of the time. Very little seems to be known in regard to their internal respiratory system. It might seem, though, that it should be simple. The nymphs are not different from the adults in this adaptation.

All these devices, as can be readily understood, are nicely correlated to the varying conditions under which the groups live. The forms with the pile and reservoir type are deep-water dwellers, the *Corixidæ* clinging to the bottom, the *Belostomatidæ* hiding among the rubbish and mud, the *Naucoridæ*, in a general way, living in the subaquatic vegetation. All comparatively seldom come to the surface; all, therefore, need some means of obtaining air while under water, which will provide a way for its constant automatic renovation independent of direct contact with the atmosphere except at comparatively long intervals. And here we have it. The air and oxygen contained in the water in some way seem to purify the air enmeshed in the pile by contact or by solution and absorption of its contained impurities. In the *Nepidæ*, the difficulty to respiration arising from long submergence is obviated by the so-called false spiracles which, in my view, act as gills and directly aerate the body fluids, which is another most striking adaptation to a special environment. The *Notonectidæ* have no remarkable peculiarity in this respect, as all come to the surface at comparatively short intervals.

In all the aquatic and semi-aquatic forms, predatory habit is the rule, and accordingly the front pair of legs is modified into powerful prehensile organs, excepting only the *Corixidæ*, of which more later. The other two pairs of legs are adapted in the purely aquatic section, in a greater or less degree to swimming, some being highly specialized and others scarcely so. In the majority of the *Belostomatidæ*, the hind pair of legs is broadened to a very marked degree, especially the tibiæ, which are heavily fringed with long hairs. These are exclusively used in locomotion under water. *Lethocerus americanus*, for instance, when hard pressed and with a free field, stretches out its raptorial front legs before it, and gives long strong propulsive strokes with the other two pairs moved synchronously. This is true also of our other native forms of the family, although, since the middle legs are neither so broad nor so powerful, the brunt of the labor is borne by the hind pair in all. When not pressed, they paddle slowly, alternating the middle and hind legs. In some of the exotic genera (*Sphærodema* and *Limnogeton*), the hind legs are prismatic and sparsely fringed, obviously representing in this respect a less specialized type, and certainly a far less agile one.

In the *Notonectidæ*, the hind pair only is used, and the legs are moved simultaneously. In passing, it may be remarked that this apparently obvious statement is repeated, because in some of the earlier observers, still quoted, it has been said that the legs alternate laterally in swimming. While in this group the legs are not so broad as in the *Belostomatidæ*, the comparatively thicker and longer hair fringe makes them very effective, and the folding back of the hairs on the return stroke tends to facilitate their use and by a species of feathering motion, avoids the retardation of a heavy back stroke. *Plea* is an exception in this family, however, in that its short little legs are narrow and set only with sparse bristles. Naturally, while the little bug swims about, it employs a short, clipping stroke, very different from the free, long, powerful movement of the others. It much prefers to walk, sometimes on the surface film, clinging back down, at others among the water weeds it frequents. The two front pairs of legs in this group are modified into raptorial legs, a rather unusual condition, and they are held closely appressed to the sternum when in repose, but when at the surface and awaiting their prey, they are somewhat outstretched and may be seen as four little eminences on the surface by the observer.

The *Naucoridæ* have legs but little adapted for swimming. They are more or less hairy or bristly, but not flattened like the legs of the Belostomatids. Nevertheless, they contrive to move quite rapidly while swimming, and some indeed, as *Aphelocheirus*, are able to breast rapid streams. On land, however, they walk quite freely for water bugs and especially so if compared with the previously named families, which are very awkward and feeble when moving on land. This difference can be readily understood if it be borne in mind that they live concealed in aquatic vegetation, among which they ordinarily creep. The raptorial front legs are very powerful in this family, the femora being greatly thickened, and the tibiæ strong and curved, terminating in a single sharp tarsal claw.

The simple legs of the *Nepidæ* are narrow, in *Ranatra* and *Amphischizops* much elongate and in *Nepa* and its Old World congeners, shorter and stouter and prismatic, with sparse hairs in all. Naturally, they are poorly adapted to swimming, and the bugs make but awkward and slow progress when in the water. *Ranatra*, for example, alternates the second and third pair of legs when swimming, a slow operation at best. In the first pair, the coxa is very long, the femur is also long, and the tibia closes over it and forms a scissors-like grasping claw.

In the *Corixidæ* also the hind legs only are specialized for swimming. The anterior pair is broadened and flattened of a more or less sickle-like shape and set with stout pegs and hairs in series. These are held by some to be in the nature of a musical organ. At least, some species make a chirping noise, which it is claimed is produced by rubbing this *strigil* as it is called, across the grooved front of the bug's face. The second pair of legs is used in clinging to pebbles and other objects at the bottom.

In the three groups, *Corixidæ*, *Belostomatidæ* and *Notonectidæ*, the legs are nearly as useless for progression on land as the wings are efficient for flying. These members have been totally modified in their adaptation to subaquatic locomotion and the very form of the insects has "suffered a sea-change;" they are smooth, narrow and more or less tapering back and front, especially toward the rear. In some, the smoothness of the exterior is produced by the greater or less polish of the hard parts—thorax, hemelytra—and in others by the possession of a pile which inhibits the natural retardation exercised by water on moving objects through friction, which is overcome by the film of air imprisoned in this pile. This device may be observed in *Notonecta*, especially in the darker forms, in which the hemelytra are to be seen silvered with a thin film of air when the bug is submerged.

Protective mimicry is exhibited mainly in *Ranatra*, which looks like a little brown twig caught in the vegetation. As it is sluggish by nature, it remains in one place and waits for its prey—*Daphnias*, young fish, free swimming aquatic larvæ of one kind or another—which it captures by means of its raptorial scissors-like forelegs as the victims incautiously swim past. The *Belostomatidæ* are more active and pounce on their prey from ambush, seizing it in their strong front claws and deadening it by injecting their narcotic saliva. They catch fish and in some parts of the world are known as fish-killers. The food of the *Corixidæ* is scarcely known, although Abbott surmises that *Rhamphocorixa acuminata* feeds on an *Ostracod*, which might lead to the conclusion that this family is no exception to the general rule in aquatic Hemiptera. It may also be presumed that they are herbivorous, as they are not fitted with the means to seize living things.

The next to engage our attention are the *Gymnocerata Littoralia*, the surface-dwellers, the water-striders, so-called, comprising the *Gerridæ* and allied families. Here, as might be expected, the environment is more uniform and we therefore find the adaptations less in number and not so unique in character as in the *Cryptocerata*. The antennæ are free, the legs are little changed in the majority, the food is animal, respiration is uncomplicated, and in general the entire structure is simpler.

The universal and most striking adaptation to life upon the waters is the greater or less thickness of the velvety pile that covers the bugs. The object of this is to prevent the insect from getting wet, by enmeshing a film of air which will repel water from its body. On the under side of the body, the pile is more or less silvery in color, while the upper side partakes of the general hue of the species. All the forms—fluviatile, lacustrine, oceanic—have this peculiarity in varying degree.

It is said that some species when closely pursued dive to escape. This submergence has actually been seen in *Rhagovelia*, but not for the purpose of escape. This form, when under water, is covered with a silvery coating of air. Although *Gerris* is said thus to evade pursuit, I have never seen any of our native species try this in spite of all manner of effort and constant attack with a net. At any rate, *Rhagovelia*, in my observation, drowns in a short time and *Gerris* does not long survive submergence.

The only other adaptation is in the structure and function of the legs. In general, in *Gerris*, the first pair is raptorial; the middle pair is used in propulsion and the hind pair as a rudder. Of the non-gerrine forms, the modified land bugs, so to speak, *Hydrometra* walks on the surface, as do *Mesovelia* and the *Hebridæ*, or *Naeogeidæ*. None of these should in any degree be deemed a true Gerrine, since they clearly belong to widely dissimilar families. In these three last named divisions, all the claws are apical and well-developed, which is also true of certain Oriental Gerrids, save that the claws in the latter are very small. In all the other water-striders, the *Gerridæ* proper, the claws of the last two pairs of feet at least are subapical and inserted in some sort of a slit. The legs in all are heavily pilose, in some few bristly. In the majority they are very slender and long, except in *Microvelia*, *Rhagovelia* and *Rheumatobates*, in which last, in some of the species of the genus, the male femora are apt to be curiously distorted; and in the other two genera much thickened. A description of the process of locomotion in *Gerris remigis*, Say, our common brown water-strider, may be taken as typical of the family *Gerridæ*. The tarsi only of the first pair of legs touch the water for support. The middle pair is used for propulsion by rowing motions, and with them they take longer or shorter strokes, according to their degree of haste, the tarsi only lying flat upon the surface and more or less outstretched. Steering is done by the hind pair mainly, and at times by a longer or shorter stroke from one or the other of the propelling feet to help. Both the tibia and tarsus of the hind pair touch the surface, the legs trailing behind the bug loosely. In the others, the *Halobatinæ*, including the *Rheumatobates* and the other lacustrine and oceanic forms, the process has been observed to be the same in some, and probably is in the others, so far as rowing with the middle feet and steering with the hind goes, but no detailed observations seem to have been made in regard to the use of the anterior feet. Nothing appears to be known in this respect about the oceanic forms. *Microvelia* moves with what Kirkaldy has called a scuttle, that is, a little run in staccato steps, but this is when not in haste. When these tiny bugs are in a hurry, they give long, powerful strokes of the middle legs, and then travel very swiftly. The most peculiar member of the group in regard to adaptation of the organs of locomotion to environment or uses is *Rhagovelia*. This genus, with two exceptions, by preference frequents the swiftest current of streams, where the waters braid in ripples, and is there to be found in schools, sometimes numbering into the thousands, as I saw them in Mexico, on the shallow Rio Santa Catarina, which runs through the City of Monterey, in the North. In these, their favorite haunts, they swim about with a zigzagging, jerky motion, against the hurrying currents, maintaining their relative positions and even surmounting the stream with little effort. Their ability to cope with a rapid flow is readily appreciated by a consideration of the structure of their legs. The anterior pair are more or less simple, as usual, and so is the posterior. Their function not having been directly observed, it can only be surmised that they do not differ from the other *Veliidæ*. The middle legs, however, are worthy of all attention. In these, the femora are more or less swollen in both sexes, greatly so in the males, not so much in the females. The tibiæ are long and slender, and the tarsi taken together are nearly as long as the tibiæ. These tarsi are highly specialized, and in them lies the secret of *Rhagovelia's* ability to breast strong currents. The last tarsal joint is split for about half its length, and in the split, at its base, is set a plume-like arrangement, which may sometimes be noticed projecting from the tarsus in dried museum specimens. A little mild speculation was excited by this plume, and Champion, in Biologia Centrali Americana, suggested that it might be spread fanwise on the surface of the water. Very fortunately a direct observation of this plume in use happened to be made and it was published, so its function is now well understood. In swimming, the tarsus of *Rhagovelia* lies on the surface along its entire length, with the split perpendicular to the surface. The plume, which is made up of a number of feather-like hairs fastened at one end at the base of the slit and free at the other, is now opened downward into the water, where it spreads fanwise, thus acting in a somewhat similar manner to the web foot of a fowl or the fin of a fish. Of course, this gives the insect a comparatively tremendous purchase and enables it to successfully propel itself against a strong flow.

A few general considerations now suggest themselves. It would seem from the facts set forth that any insects provided with such highly specialized devices fitting them to cope with a complex environment can scarcely be considered primitive forms, not if evolution be operative as is commonly asserted and with simple scientific faith believed to be. Whatever structures are seemingly simple can be explained by the fact of disuse or by non-specialization due to unspecialized use.

As an example, consider the hind wings of *Ranatra.* This insect is obviously highly specialized, but these wings have few if any cross-veins, and these few are mostly spurs arising from the longitudinal veins. Equally obviously, such very narrow wings as this insect has do not require stiffening cross-veins, and in the course of time those that once were there became obsolete. In *Aphelocheirus*, the insect's frequentation of never-drying streams makes even the adventitious use of wings unnecessary for any purpose, and so through ages of disuse they have totally disappeared. Again, how by any stretch of imagination can such a complex organ as the tarsal plume of *Rhagovelia* be considered a primitive structure? In the whole range of insects there is no similar highly specialized swimming device known. No further comment on this phase of the subject seems necessary.

The true position in time of the highly interesting groups of aquatic Hemiptera is to be determined by a careful consideration of the volume of important work that has appeared in Europe and elsewhere on the structure and habits of this series of insect forms, a series which displays so many highly specialized (and therefore *not* primitive) adaptations to a very special environment.

KEY TO THE NEARCTIC SPECIES OF PARACALOCORIS. (HETEROPTERA; MIRIDÆ).

By W. L. McAtee.

The genera *Calocoris* Fieber and *Paracalocoris* Distant are very closely related if indeed they are not identical. They belong to the sub-family Mirinæ and to the tribe Capsini. In these insects the body is not constricted at middle, the cheeks are narrow, hind femora slender, pile of first antennal joint not dilated apically, first joint of tarsus short, last two joints of antennæ distinctly slenderer than second, and the head as seen from side about as long as high at base.

The characters thus far advanced for separating *Paracalocoris* from *Calocoris* are not constant, and the writer must leave to someone having ample material of the latter, the problem of ascertaining whether the two groups really are generically distinct. As used in this paper *Paracalocoris* includes species having the characters above outlined and in addition the following: Pronotum with two discal, subexcavated, velvety black spots, and left clasper of male with a large rounded or pointed lobe on upper side at base. In *Calocoris* as represented by *alpestris* Meyer, *fulvomaculatus* DeGeer, and *norvegicus* Gmelin; the clasper has no such lobe at base, and in the last-named species is much slenderer throughout.

Species that have been referred to *Paracalocoris*, probably erroneously, include two described by Herrich-Schaffer. One of these, *Capsus tetrastigma** has been placed in Resthenia by Stal.† The other, *Capsus externus*,‡ in the writer's opinion, is not a *Paracalocoris*. It is true that the two central velvety black spots on the thorax mentioned in the original description suggest that the insect is a member of this genus, but no *Paracalocoris* has the first antennal joint "as long as head and thorax together," a condition plainly stated in the description and delineated in the illustration of *Capsus externus*. If the statement regarding the antenna is correct, *C. externus* does not belong to the genus now under consideration. If incorrect and the species really is a *Paracalocoris*, it may be closely related to *P. scrupeus* var. *bidens* n. var., or to *P. limbus* n. sp. From the former, it would be at least varietally distinguished by the four-lobed black marking across posterior part of thorax and from the latter by the scutellum being pale reddish instead of fuscous.

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*Die wanzenartigen Insecten. Bd. 9, Nurnberg, 1853, pp. 166-167.

†Hemiptera mexicana enumeravit speciesque novas descripsit. Entomologische Zeitung (Stettin). Jahrgang 23, Nr. 7-9, July-September, 1862, p. 317.

‡Wanz. Ins. 8, 1848, p. 16.

In preparing the key to *Paracalocoris* the writer strove to base it entirely upon fairly constant structural characters and was successful except for the *colon* group. This section is considered to consist of three species, and color pattern is used as a key character. The dangers of the latter course are well illustrated by the several distinct color patterns exhibited by the varieties of *P. scrupeus*, but which nevertheless are practically identical structurally. The writer is convinced that basing classification upon structure, so far as possible is an ideal distinctly worth while. Could it be consistently applied the experience of the student of systematic entomology would be much more satisfactory.

For the loan of material the writer is indebted to Messrs. J. C. Crawford, Otto Heidemann, W. D. Pierce, Wm. T. Davis and H. H. Knight. Mr. Knight kindly gave me for inclusion in this paper descriptions of the new species *hawleyi* and new variety *ancora*, forms upon which he had made economic investigations in New York and which he had already determined as undescribed.

The key includes the following species and varieties:

Species	*Old*	*New*	*Varieties*	*Old*	*New*
10	6	4	26	3	23

With regard to varieties, the writer would remark that placing together in a collection the often very distinct appearing color varieties results in a heterogeneity that inevitably suggests that classification has not been properly done. The use of names for the varieties not only encourages separation of them in collections but facilitates reference to them and is one of the steps necessary to a better understanding of their significance.

KEY TO SPECIES.

A. Hind tibiæ with long hairs standing out all around, obscuring tibial spines..1. **scrupeus Say.**
AA. Pilosity of hind tibiæ more appressed, especially on inner side; not so abundant and spreading as to obscure spines.
  B. First antennal joint as long as, or longer than thorax.
    C. Greatest width of thorax over 2 mm., color everywhere except discal spots and membrane a lighter or darker reddish brown..2. **adustus** n. sp.
    CC. Greatest width of thorax under 2 mm., coloration not as above, 3. **hawleyi,** H. H. Knight, n. sp.
  BB. First antennal joint shorter than thorax.
    D. Upper surface polished, very sparsely haired.
      E. Second antennal joint considerably less than 2 mm. long. 8. **jurgiosus** Stal.
      EE. Second antennal joint considerably more than 2 mm. long. 10. **deleticus** Reuter
    DD. Upper surface not polished and with numerous hairs.
      F. Second antennal joint 2.4 mm. long or longer.
        G. Thorax 2.3 mm. wide..........................4. **limbus** n. sp.
        GG. Thorax less than 2 mm. wide...............9. **acceptus** n. sp.
      FF. Second antennal joint 2.2 mm. long or less.
        H. Color yellow-brown to brown, the principal markings consisting of 11 symmetrically arranged pale yellow patches, of which a usually conspicuous and always distinguishable one covers the apical third of scutellum. 7. **multisignatus** Reuter.
        HH. Color pattern not as above.
          I. Color pattern when fully developed, consisting of pale golden longitudinal vittæ (the longest following cubitus to apex of corium) upon rich mahogany red ground; the insect may be almost wholly pale golden, but the apex of corium never has a distinct dark marking...6. **heidemanni** Reuter.
          II. Color pattern not as above; the whole insect may be fusco-stramineous, but the apex of corium (just inside cubitus) always has a distinct fuscous to piceous marking. 5. **colon** Say.

1. **Paracalocoris scrupeus** Say.

C. [*apsus*] *scrupeus* Say, * Descriptions of new species of Heteropterous Hemiptera of North America, New Harmony, Indiana, December, 1831, p. 22.† The complete writings of Thomas Say on the entomology of North America, Vol. I, 1859, pp. 342-343. (United States).

This species is distinguished from all the other Nearctic forms by the character of the pilosity of the hind tibiæ. The abundant long hairs on this part of the leg stand out in all directions and almost completely conceal the tibial spines. The presence of spreading hairs on the *inner side* of hind tibia especially is diagnostic, since in other species the pilosity of the inner side invariably is appressed. In specimens having the pile of hind tibiæ mostly rubbed off, the presence of a few *outstanding* hairs on *inner* side of tibiæ usually is sufficient indication that the specimen belongs to the *scrupeus* group.

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*References are given in full the first time cited and abbreviated thereafter.

†Pagination of this paper according to Banks, N., Catalogue of the Nearctic Hemiptera-Heteroptera, 1910, p. 47.

Measurements:* Total length 6–7.5 mm.; width of thorax across front .7–.73 mm., across posterior angles, 1.73–2.3 mm., length of thorax (seen from side) 1.16–1.6 mm.; length of antennal joints; first, 1.6–1.63 mm., second 1.9 – 2.66 mm., third .7–.9 mm., fourth .83–.9 mm.

Range: The specimens examined came from the region marked off by the following states: New York, North Dakota, Texas and Virginia.

Paracalocoris scrupeus divides into numerous color varieties, of which those seen may be separated as follows:

a. Costal margin of hemelytra of about the same color as disc of corium; cuneus sometimes dusky red.

b. Thorax with dark markings in addition to the discal spots.

c. Thorax with typical dark markings, that is: portion anterior to discal spots or less piceous or only dusky, and usually piceous dots or more or less dusky clouding near posterior angles.

d. Corium fusco-piceous.......................... var. *scrupeus* Say.

dd. Corium dark red, cuneus a little lighter........ var. *rubidus* n. var.

cc. Thorax otherwise marked.

e. Thorax very dark.

f. Scutellum mostly yellowish or reddish; thorax all dark above except for a median and two lateral areas in line with the discal spots.................................... var. *triops* n. var.

ff. Scutellum dark.

g. Scutellum piceous; thorax with two lateral yellow areas. var. *diops* n. var.

gg. Scutellum dusky with median light vitta, spots on clavus and corium yellowish red...................... var. *delta* n. var.

ee. Thorax all light, except for indistinct vittæ and dusky maculations from discal spots to posterior margin, and between these and lateral margins; a broad pale vitta traversing scutellum, thorax and top of head; corium yellow brown................ var. *percursus* n. var.

bb. Thorax without definite dark markings in addition to discal spots.

h. Corium red-brown with yellow dots....... var. *compar.* n. var.

hh. Corium except apex, and clavus except base and thin inner margin, uniform orange red; the extreme form of var. *ardens* n. var.

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*Intended to show merely the ordinary range of variation.

All measurements were taken with eye-piece micrometer in Zeiss binocular using No. 1 eyepieces and A-2 objectives, which combination yields a magnification of 20. The measurement, length of thorax, is taken with the insect viewed from side and is the direct length from upper front to upper hind margin, disregarding the curvature of dorsum. To have a definite point for beginning, the measurement of first antennal joint is always from constriction above basal knob.

aa. Costal margin of hemelytra, at least the cuneus distinctly lighter in color than disc of corium.
  i. Cuneus and sometimes spots on corium lighter in color than disc.
    j. Thorax with typical markings (see c, above).......var. *cunealis* n. var.
    jj. Thorax otherwise marked.
      k. Thorax dark or dusky, with light vittæ from just outside discal spots toward posterior margin, and a light central patch sometimes prolonged toward hind margin.
        l. Scutellum dark, with distinct median light vitta....var. *par.* n. var.
        ll. Scutellum sordid or clouded yellowish............var. *sordidus* n. var.
      kk. Thorax except discal spots and anterior third, scutellum, cuneus and elytral maculations, pale yellow...................var. *lucidus* n. var.
  ii. The whole costal margin reddish or yellowish.
    m. Thorax without dark markings between discal spots and hind margin.
      n. Discal boot-jack shaped area dark, bounded by lighter elytral margins, scutellum and thorax..............var. *bidens* n. var.
      nn. This marking practically obsolete; upper surface except membrane, inner angle of corium and base and thin inner margin of clavus reddish or yellowish................var. *ardens* n. var.
    mm. Thorax with dark markings between discal spots and hind margin.
      o. Typical dark marking on anterior third of thorax.
        p. Scutellum dusky with median light vitta.
          q. Clavus and adjacent parts of corium, and the membrane dusky..............................var. *nubilus* n. var.
          qq. Clavus and adjacent parts of corium spotted with yellowish red...................................var. *delta* n. var.
        pp. Scutellum mostly light; median light vitta, bounded by two more or less complete wedge-shaped dark ones; clavus and corium spotted with yellow............var. *varius* n. var.
      oo. No dark marking on anterior third of thorax..var. *bicolor* n. var.

Paracalocoris scrupeus var. **scrupeus** Say. (Loc. cit.)

Head in lightly marked individuals fuscous with pale yellow lineations medially above, over and under eyes and antennal sockets and across front of tylus; under surface of head pale yellow. All these markings may be more or less obscured by fuscous. Antennæ fusco-piceous, 3rd and 4th joints sometimes pale at base. Thorax and scutellum orange (orange chrome)* to pale red (jasper red); anterior third of thorax dusky to piceous, and dots or more or less clouding in same colors near posterior angles; scutellum more or less margined with dusky to piceous, median line often paler than ground color. Sides of prothorax with alternating pale and fuscious lines, usually connected by at least an oblique pale streak on meso and meta-thorax, to the pale markings along sides of venter.

Hemelytra fusco-piceous, tending in some specimens to show a reddish tinge, especially at the cuneus; membrane dusky.

Legs fusco-piceous, femora sometimes with pale yellow maculations and front and intermediate tibiæ with one, hind with 2 pale annuli. Venter pale fuscous to piceous; lightly pigmented individuals have from one to three series of pale markings across outer parts of abdominal segments.

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*When convenient, color names were taken from Color standards and color nomenclature,, by Robert Ridgway, Washington, D. C., 1912.

Batavia, N. Y., 19♂, ♀, June 20-27. On Crataegus, wild apple, and wild cherry. H. H. Knight. (K, M.)† A specimen without locality bears the label "on oak." (N. M.)

Niagara, N. Y., July 5, 1904, 1 ♀ (H.).

Beltsville, Md., June 9 and 14. 3 ♂ ♀ on Psedera quinquefolia. W. L. McAtee (M.). One of these specimens has intensified thoracic markings, and approaches var. *triops* (see below).

Bluemont, Va., July 1, 1914, 2♂. W. L. McAtee. (M.)

Paracalocoris scrupeus var. **rubidus** n. var.

Head much as in typical variety; first joint of antennæ reddish testaceous to reddish and fuscous at base. Thorax and scutellum orange red (dragons blood red to Brazil red), dusky markings near posterior angles of thorax almost or quite obsolete.

Hemelytra chiefly dark red (morocco red), varying to piceous on clavus and apex of corium; costal edge of corium with small dull testaceous patches; cuneus blood red (garnet brown) to morocco red; membrane dusky.

Femora pale spotted and tibiæ each with two light and three dark annuli, the terminal one of latter narrow; these markings sometimes obsolete.

Batavia, N. Y., June 28, 1914, 1 ♀, H. H. Knight, Type. (K.)

Stony Island, N. Y., July 8, 1896, 1 ♀ (N. M.).

Paracalocoris scrupeus var. **triops** n. var.

Coloration as in typical variety except that thorax has much more extensive dark markings. A median area between discal spots, sometimes extending more or less toward hind margin and two areas just laterad of discal spots and continuing over sides, yellowish or reddish. Scutellum more heavily margined with piceous than in typical variety.

A pale (immature) specimen of this variety has the femora and basal joints of antennæ pale yellowish maculate.

A very dark specimen has discal thoracic marking reduced in size, and two triangular piceous markings bordering median line at base of scutellum.

Pine Island, N. Y., June 19, 1912. 1 ♀, Wm. T. Davis, Type (K.).

Staten Island, N. Y., June 17, 1912. 1 ♂ Wm. T. Davis, (H.).

1 ♀ without locality (N. M.).

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†The initials in parentheses indicate present owners of specimens. Those used and their significance are as follows: D—Wm. T. Davis, H.—Otto Heidemann, K.—H. H. Knight, M.—W. L. McAtee, and N. M.—U. S. National Museum.

Paracalocoris scrupeus var. **diops** n. var.

Coloration as in typical variety except that scutellum is entirely fusco-piceous, and thorax of same color except for yellow patches laterad of discal spots, which extend irregular projections toward hind margin. There are faint pale points also along median line.

1 ♂ Lakehurst, N. J., June 30. Wm. T. Davis. Type (H.)

Paracalocoris scrupeus var. **percursus** n. var.

A pale variety; head pale testaceous, an oval patch of dark herring bone markings between bases of antennæ, which is traversed by a pale vitta extending forward over tylus; patch on side of latter and stripe from front of eye to tylus shining light brown. Antennæ testaceous, first joint sprinkled with reddish brown or fuscous markings; second joint with same color varying in extent at base and apex; third and fourth joints more or less broadly tipped with same.

Thorax with a median percurrent area of varying extent pale testaceous; remainder of upper surface more or less fuscous irrorate or vittate.

Scutellum pale testaceous, median percurrent area clear; remainder with fuscous markings which tend to be arranged in two pairs of vitta, one set paralleling median clear area and the other lying on lateral margins of scutellum.

Hemelytra yellow-brown (hazel), clavus narrowly edged internally with black; cuneus yellowish red (rufous); membrane dusky with clearer areas.

General color beneath pale testaceous; the series of markings along sides which in the typical variety contrast with the ground color, here are of that color, but are set off by more or less fuscous edgings. Legs testaceous, fuscous irrorate.

In this variety the pilosity of hind tibiæ is rather sparse; the first joint of antenna also is consistently though slightly shorter than thorax; hence the variety is not so closely linked to *scrupeus* as are the others. For the present, however, it seems best to give it the status here assigned. The form is easily recognized by the broad pale marking percurrent over head, thorax and scutellum.

Plummers Island, Md., June 7, 1914, W. L. McAtee. 1 ♂ Type (M.).

Plummers Island, Md., June 30, 1907, A. K. Fisher. 1 ♂ (M.).

Four-mile Run, Va., May 31, 1914, Alex. Wetmore. 1 ♂ (M.).

District of Columbia, 1 ♀ (N. M.).

Paracalocoris scrupeus var. **compar** n. var.

Head sordid-testaceous; area between bases of antennæ with faint fuscous herring-bone markings broken along median line. Antennæ: First joint, pale fuscous; second joint, apical third and narrow ring at base fuscous, remainder testaceous; third joint, apical third fuscous, remainder testaceous.

Thorax above sordid-testaceous in front of discal spots, elsewhere vinaceous red with indistinct paler areas. Scutellum reddish-fuscous with median reddish-yellow vitta. Corium red-brown with reddish-yellow spots; fuscous at apex. Clavus fuscous along inner margin. Cuneus clearer red-brown with clustered reddish-yellow spots. Membrane vitreous, dusky clouded.

Color beneath mostly reddish fuscous with reddish yellow markings. Legs sordid-testaceous; usual dark markings faintly indicated.

West Point, Nebr., June, 1888. 1 ♂, Type (N. M.).

This variety is almost a perfect match in color for some specimens of *P. colon* var. *colonus*.

Paracalocoris scrupeus var. **cunealis** n. var.

This differs from typical variety only in always having the cuneus of a lighter color than disc or corium, that is yellowish to reddish; usually a few spots of the same color elsewhere on hemelytra, especially on the part next to cuneus. Basal part of cubitus also usually pale.

Batavia, N. Y., June 20 to July 6. Numerous specimens. H. H. Knight. On wild apple, Crataegus and Quince. (K, M.) 1 ♂, June 27, 1913 is the type. (K.)

Onaga, Kansas, 1 ♂, Crevecoeur. (N. M.)

Paracalocoris scrupeus var. **lucidus** n. var.

Similar to last, but thorax except discal spots and part anterior to them, scutellum, cuneus, elytral maculations, and cubitus, pale yellow.

Batavia, N. Y., July 6, 1914. 1 ♀, H. H. Knight. Type (K.).

Paracalocoris scrupeus var. **par.**

Head and antennæ as in typical variety.

Thorax above fusco-piceous except narrow yellowish-to reddish-orange vittæ beginning just outside discal spots and extending to near hind margin, a central patch of same color sometimes prolonged toward hind margin; and sometimes also smaller spots elsewhere. Scutellum fusco-piceous with more or less distinct yellowish to reddish orange median vitta; sometimes traces of two other vittæ midway between median one and basal angles. Hemelytra fusco-piceous; cubitus, maculations (sometimes indistinct) near margin, especially toward cuneus yellowish to reddish yellow. Cuneus sometimes of same coloration, but varying to clearer reddish (Brazil red). Membrane dusky.

Legs with light markings rather pronounced. Coloration much like that of *P. hawleyi* var *pallidulus* n. var.

Ithaca, N. Y., June 21, 1915. 1 ♂, Type (K.).

Same data, 1 ♀. Batavia, N. Y., June 20, 1915, 1 ♂.

Portage, N. Y., June 27, 1915. 1 ♂. All collected by H. H. Knight. (K, M.)

Rochester Jct., N. Y., June 16, 1914, 1 ♂. M. D. Leonard. (H.)

Willow Springs, Ill., July 3, 1904. 1 ♀. On wild grape. W. J. Gerhard. (H.)

West Point, Nebr., May 26, 1885. 1 ♀ and a ♂, with label Nebr. (N. M.)

Paracalocoris scrupeus var. **sordidus** n. var.

Similar to variety *par*, the principal difference being that scutellum except the sloping lateral portions is sordid yellowish, paler along median line. The maculations of hemelytra are not so distinct as in *par* and the dark markings of thorax tend to be merely fuscous cloudings.

Batavia, N. Y., June 30, 1914. 1 ♂. H. H. Knight. Type (K.)

Nebraska, 1 ♂. (N. M.)

Paracalocoris scrupeus var. **bidens** n. var.

Head and antennæ as in typical variety.

Thorax with typical markings, except that clouding near posterior angles may be absent. There are in some specimens traces of dark markings at middle of hind margin of thorax and on anterior median part of scutellum. Scutellum sometimes rather sordid with lighter median vitta. Otherwise, thorax, scutellum, and broad lateral portions of hemelytra, yellowish to red, brightest on cuneus; enclosing a discal boot-jack shaped fuscous to piceous area, which is sometimes invaded by pale maculations. Membrane dusky.

I group with this variety all specimens varying toward var. *ardens* (see below), but not clearly that form.

Beltsville, Md., June 14, 1914, on Virginia creeper, 1 ♂ Type. W. L. McAtee (M.).

Pine Island, N. Y., June 14, 1912, 1 ♂, and Staten Island, N. Y., June 17, 1 ♂. Wm. T. Davis (D.).

Batavia, N. Y., June 14 to 30, many specimens. On wild apple and Crataegus. H. H. Knight (K, M.).

Ithaca, N. Y., June 21, 1915. 1 ♀ and June 1911, 1 ♂. H. H. Knight (K.).

Lakehurst, N. J., June 30, 1 ♀; Singae, N. J., June 15, 1 ♂, and Ramsey, N. J., June 23, 1912, 1 ♀. Wm. T. Davis (D.).

Allegheny, Pa., no date, 1 ♀. (N. M.)

Beltsville, Md. Numerous specimens, June 9 and 14 and July 4. On *Psedera quinquefolia*. W. L. McAtee (M, K.).

Plummers Island, Md., June 5, 1903. 1 ♂, W. V. Warner (N. M.).

Washington, D. C., August 9, 1884. 1 ♂ (H.).

Bluemont, Va., July 1, 1914. On Virginia creeper. 2 ♀, W. L. McAtee (M.).

Victoria, Texas, April 11 and 20. On *Quercus virginianus*. 1 ♂, 1 ♀, J. D. Mitchell (N. M.).

One ♀, without locality, but with label, "on oak," June. (N. M.)

Paracalocoris scrupeus var. **ardens** n. var.

Upper surface yellowish to reddish, practically without dark markings; faint dark markings tend to persist at apex of corium, along inner edge of corium and clavus and on vertex. Membrane smoky.

Willow Springs, Ill., July 3, 1904. On wild grape. W. J. Gerhard. 1 ♀. Type (H.)

Great Falls, Va., May 30, 1907. 1 ♀. O. Heidemann. (H.)

Chain Bridge, Md., June 9, 1905. 1 ♀. D. H. Clemons (N. M.)

Paracalocoris scrupeus var. **nubilus** n. var.

Head and antennæ as in typical variety.

Thorax above fuscous before discal spots, two widening fuscous vittæ extending from discal spots to hind margin of thorax. Thorax elsewhere dusky vinaceous red, fading to yellowish just outside each discal spot and along median line behind.

Scutellum fuscous, fusco-piceous at base, reddish elsewhere with yellowish brown median vitta.

Clavus and adjoining parts of corium, and apex of latter fusco-piceous. Remainder of corium reddish, variegated with paler; cuneus clear light reddish, fuscous at apex. Membrane dusky with faint pale areas.

Portage, N. Y., June 21, 1914. 1 ♂ Type. H. H. Knight (K.).

Paracalocoris scrupeus var. **delta** n. var.

Head as in typical variety; antennæ, first joint, fuscous at base, testaceous sprinkled with reddish fuscous beyond; second to fourth each fuscous with a narrow testaceous annulus at middle, another at base.

Thorax above chiefly piceous; yellowish red to orange red sprinklings as follows: About discal spots and in three pseudovittæ toward hind margin, one outside each discal spot and one median, the latter diffuse; also a series of spots near hind margin.

Scutellum fusco-piceous with narrow orange-red median vitta. Clavus fusco-piceous sprinkled with reddish yellow along outer edge. Corium orange-red, spotted with yellow, fusco-piceous along cubitus and at apex. Cuneus clearer reddish with a few yellowish spots. Membrane dusky with large pale areas.

Color beneath fuscous to piceous the usual markings in yellowish and reddish; legs fuscous, femoral spots and tibial annuli testaceous.

Willow Springs, Ill., July 3, 1904, 1 ♀. On wild grape. W. J. Gerhard. Type. (H.)

Paracalocoris scrupeus var. **varius** n. var.

Head, antennæ and legs pale, but with the typical markings recognizable.

Thorax above reddish-orange, with transverse band in front of discal spots and broken vittæ from latter to hind margin, fuscous to piceous; sometimes sprinkled with pale fuscous or yellowish elsewhere.

Scutellum of same reddish-orange color or somewhat darker with paler median vittæ, set off by dark markings beginning at base and extending varying distances apically. Hemelytra of same ground color; clavus and apex of corium fuscous, sometimes fuscous cloudings elsewhere and usually yellow flecks paler than ground color. Cuneus clearer reddish. Membrane dusky with pale areas.

Batavia, N. Y., June 27, 1913. On wild apple. 1 ♀. Type. H. H. Knight (K.) Two other females with same data. (K, M.)

Paracalocoris scrupeus var. **bicolor** n. var.

Head rather pale, antennæ piceous, legs reddish fuscous.

Thorax above, reddish in front of discal spots, and between them, the latter marking extending toward hind margin, which is narrowly edged with reddish; remainder of upper surface fusco-piceous.

Scutellum dark red, lighter at base and apex.

Hemelytra fusco-piceous, except base of cubitus, narrow costal margin, apex of clavus and cuneus, which are dark red. Membrane fuscous.

Victoria, Texas, April 20. On live oak. 1 ♂. Type. J. D. Mitchell. (N. M.)

Paracalocoris adustus n. sp.

Length 8 mm., length of thorax 1.46 mm.; width of thorax, front, .8 mm., back 2.2 mm.; length of antennal joints: first 1.6 mm.; second 2.53 mm.; third 1.16 mm.; fourth 1.1 mm.

Color an almost uniform reddish brown, a little lighter on cuneus and lower surface and inclining to fuscous on antennæ, tibiæ and inner margin of elytra; membrane dusky. Short pale yellow hairs abundant on upper surface, except membrane.

Lakehurst, N. J., June 13, 1908, 1 ♀ (Type), Wm. T. Davis (D.).

Paracalocoris hawleyi H. H. Knight, n. sp.

Elongate and more slender than *P. colon.* Color, fusco-piceous to piceous, rubiginous in immature specimens, with outer margin of the hemelytra sordid hyaline or pale yellowish and cuneus reddish. Pubescence more sparse and not noticeably golden yellow, as in *P. colon.* Total length 6 mm.

♂. Head: Eyes and face dark brownish to black; posterior part of the eyes, a semicircular mark between and in front of the eyes, nearly joining across the vertex, pale to orange-red. Width of head across the eyes, 1.08 mm., width between eyes, .51 mm., length of dorsal aspect, .6 mm. Rostrum reaching to posterior margin of the hind coxæ, amber brown or fuscous, two basal segments more or less pale at apex; two apical segments darker. Antennæ: Segment 1, length 1.37 mm., reddish black, densely hairy with a few scattering spines which stand out from the partly decumbent hairs; segment II, length 2.2 mm., thicker on apical half, brownish black with fine pubescence; segment III, length 1 mm., blackish, pale at the base, with very fine silvery pubescence; segment IV, length 1.19 mm., like the preceding, only slightly more slender.

Pronotum: Length 1.14 mm., width of base 1.88 mm., apex .82 mm.; color fusco-piceous, sometimes with apical half yellowish; front, sides and a very narrow margin extending around base of pronotum, pale; two jet-black, opaque, sub-excavated spots, one behind each callus, with a pale area bordering the outer margin of each. Scutellum fusco-piceous with a pale median, longitudinal line or trace thereof, some specimens having this line produced on the pronotum.

Hemelytra: Greatest width 2.02 mm.; clavus fusco-piceous as is that part of the corium inside of the cubital vein; corium exterior to the cubitus, pale yellowish, sometimes tinged with orange; cuneus reddish orange with basal and narrow outer margin paler; membrane and veins fuscous, with a clear spot along the margin near the apex of the cuneus.

Legs fusco-piceous, with small pale yellowish to reddish spots on the femora especially near the apices; hind tibia with two pale rings, sometimes not distinct, the larger taking up of the apical fourth; tarsi pale, with the tips fuscous. Venter fusco-piceous, a series of 3 or 4 narrow pale lines on its margins in some specimens reduced to spots.

Female essentially the same as the male, but slightly more robust and especially so when filled with eggs. In typical specimens both sexes are of the same color.

Paracalocoris hawleyi var. **ancora** Knight, n. var.

Similar to *hawleyi*, but differs in having the hemelytra entirely fusco-piceous, cuneus dark reddish with the very apex fuscous; costal vein and base of cubitus noticeably pale; median longitudinal pale stripe of scutellum quite plain and is usually joined by a similar stripe extending from the base of the pronotum forward between the two sub-excavated black spots.

This species and variety are described from a large series of specimens collected on hop vines near Waterville, N. Y., from July 18th to September 1, 1914 and 1915. The writer has seen two specimens from Brookline, Mass.

The species is named for Mr. I. M. Hawley, who during the last two years has worked out the life history of the insect near Waterville, N. Y., where it is becoming a pest of economic importance on the cultivated hop. The life history of the species will soon be published by Mr. Hawley.

P. hawleyi and *P. colon* both may be distinguished from *P. scrupeus* and its varieties by the shortness of the pubescence on the posterior tibiæ, which is never long and prominent enough to obscure the true spines. *P. hawleyi* differs from *P. colon* in being more slender and elongate; hemelytra more parallel-sided and in color, fusco-piceous with outer margin pale or reddish yellow; variety *ancora* with the hemelytra almost entirely fusco-piceous without the pale margin. The pubescence of *P. hawleyi* is more sparse and less golden yellow; dorsum not variegated with paler maculæ as in the case in our local variety of *P. colon*. *P. hawleyi* feeds on hops and appears later in the season than *P. colon*. In 1915 the species began maturing about July 18th and adults continued to emerge up into the first week in August. Adults were most numerous from July 25 to August 20, while occasional adults are found in September. *P. colon* was found breeding in considerable numbers on the tender shoots of apple trees near Batavia, N. Y. In 1915 the first adult was taken June 19th and the majority of the species had emerged by July 7. Adults were very scarce by July 23 and none were taken after July 31.

The writer of the present paper desires to name two other color varieties of *Paracalocoris hawleyi*. These and the two described by Mr. Knight may be distinguished as follows:

A. With lateral pale stripe whole length of corium.
  B. This stripe undivided, though it may contain a dark blotch especially at about middle of costal margin.................var. **hawleyi** Knight.
  BB. Stripe divided by a dark vitta broader posteriorly, leaving a very narrow pale costal margin.................................var. **fissus** n. var.
AA. Without such stripe.
  C. Hemelytra except cuneus almost uniform in color, though cubitus and costa may be pale..............................var. **ancora** Knight.
  CC. Hemelytra and other parts of upper surface more or less spotted with yellow...................................var. **pallidulus** n. var.

Immature specimens are reddish throughout, though the color pattern is indicated by different shades. Specimens nearly mature may be dusky red, but when fully mature the ground color of *hawleyi* is fusco-piceous to piceous.

Paracalocoris hawleyi var. **hawleyi** Knight.

Waterville, N. Y., July 23, 1915, I. M. Hawley, 1 ♂ (Holotype) (K.).

Waterville, N. Y., July 27, 1915, I. M. Hawley, 1 ♀ (Allotype) (K.).

Waterville, N. Y., July 27 to August 18, 1915, I. M. Hawley, 3 ♂, 2 ♀ (K, M., N. M.).

Waterville, N. Y., July 7, 1913, G. W. Herrick, 4 ♂ (N. M., H.). These specimens are all immature and are very reddish. Another male with same date (H.) has thorax largely, costal stripe, tips of clavi and other pale markings ochreous and cuneus pale sanguineous.

Waterville, N. Y., August 5, 1913, I. M. Hawley, 1 ♂ (H.).

Beltsville, Md., June 14, 1914, W. L. McAtee, 4 ♂, 2 ♀ (M.).

Paracalocoris hawleyi var. **fissus.** n. var.

Differs from *hawleyi* in having the pale costal margin divided by a mahogany red to fuscous streak from humerus to cuneal suture. This streak, which is broader posteriorly, leaves only a thin pale costal streak and a wider but more irregular one along cubitus. Two specimens have a pale streak along claval vein, and a shorter one along brachial vein.

Beltsville, Md., June 14, 1914, W. L. McAtee, 1 ♂ (Type) (M.).

Same data also 3 ♀, 1 ♂ (M.).

Staten Id., N. Y., June 19, W. T. Davis, 1 ♂ teneral, and color not fully developed. (D.)

Paracalocoris hawleyi var. **ancora** Knight.

Waterville, N. Y., August 2, 1914, I. M. Hawley, 1 ♂, (Holotype) (K.).

Waterville, N. Y., August 21, 1914, I. M. Hawley, 1 ♀, (Allotype) (K.).

Waterville, N. Y., August 18-22, 1914, August 1-18, 1915, I. M. Hawley, 5 ♂, 1 ♀, (K, M., N. M.).

Waterville, N. Y., July 7, 1913, G. W. Herrick, 1 ♂, immature (N. M.).

Waterville, N. Y., August 5, 1913, I. M. Hawley, 1 ♂, (H.).

Ithaca, N. Y., upon hops, G. W. Herrick, 1 ♂, immature (H.).

Batavia, N. Y., July 15, 1913, June 24 to July 26, 1914, July 27-31, 1915, H. H. Knight, 6 ♂, 1 ♀, (K, M.).

Beltsville, Md., June 14, 1914, W. L. McAtee, 4 ♂, (M.).

Paracalocoris hawleyi var. **pallidulus** n. var.

Agrees with *ancora* in lacking broad pale costal margin, but differs from that variety in having the corium especially posteriorly, and usually the scutellum and thorax, dotted with small pale yellowish spots in addition to the usual pale markings.

Batavia, N. Y., June 24, 1914, H. H. Knight, 1 ♀, Type (K.).

Same locality, July 25, 1913, June 30, 1914, July 25 and 30, 1915, H. H. Knight, 3 ♀, 1 ♂, (K, M.).

Paracalocoris limbus n. sp.

Length 7.5 mm.; length of thorax 1.56 mm., width of thorax: Front, 1 mm., back 2.33 mm.; length of antennal joints: First 1.5 mm., second 2.56 mm., third 1.16 mm., fourth 1.33 mm.

Top of head, a marking on base of thorax, with anterior lobes reaching discal spots, and shorter lobes outside of these, scutellum and hemelytra except broad exterior margins fuscous; membrane dusky. Remainder of upper surface yellowish red, palest on edge of corium, deepest on front of thorax. First joint of antenna piceous, with copious coarse hair of same color; color of remaining joints and pubescence thereof successively paler, the third being fuscous, and the fourth testaceous with abundant, fine whitish hair.

Legs fusco-piceous, spots on femora and the tarsi pale. Under surface yellowish red with fuscous markings.

Clayton, Ga., 2000-3700 ft., June, 1909, 1 ♀ (Type), Wm. T. Davis, (K.).

Paracalocoris colon Say.

C. [apsus] colon Say, Heteropterous Hemiptera of North America, New Harmony, Indiana, Dec., 1831, p. 25. Complete writings, Vol. I, 1859, pp. 346-347. (Indiana).

It is not absolutely certain that the name *colon* is applied here to the precise form described by Say. For instance, Say describes the second antennal joint of *colon* as "whitish in the middle and for a short space at base, and blackish at tip." As color characters go in *Paracalocoris* those of the antennæ are perhaps the most constant. Yet in all the specimens, I have examined of what is here accepted as the *colon* group, not one agreed with the original description in coloration of the second joint of the antenna. *Paracalocoris multisignatus* Reuter, however, agrees perfectly in this particular and is the only species having just that coloration. Nevertheless the remainder of the description of *colon* does not fit *multisignatus*, and in particular the conspicuous pale spot invariably present on apical third of scutellum of the latter species is not mentioned. This could hardly be overlooked. In the absence of type specimens, therefore it is best to preserve the names as they are customarily applied. It is possible, futhermore, that a specimen of the typical variety with proper antennal coloration may sometime be found, in which case all doubts will be removed.

Description of Nymphs.

Two nymphs evidently of this species, collected at Beltsville, Md., June 9, 1915, on Psedera quinquefolia, W. L. McAtee (M.), may be characterized as follows:

Length 4-4.5 mm.; length of thorax .66 mm.; width of thorax: front .703-.806 mm.; back 1.2 mm.; distance from back of thorax to tip of wing pad 1.6 mm.; length of antennal joints: first 1 mm.; second, 1.8 mm.; third .8-1 mm.; fourth .806 mm.

General color, yellowish green or sordid testaceous, fusco-piceous on tips of wing pads, and sometimes on head. Antenna: first joint light greenish to reddish, with copious black pile; second joint, basal two-fifths, stramineous, remainder reddish, varying to piceous, with copious black pile, more abundant apically; third joint greenish, apical third blackish, also with longer and more copious pile than usual; fourth joint pale. Femora when marked, reddish or fuscous with yellowish spots; tibiæ with two dark and two pale annuli; tarsi dark at tip.

Paracalocoris colon may be divided into color varieties as follows:

A. Hemelytra entirely pale (stramineous to reddish) or with markings (besides that at apex of corium) darker than ground color.
  B. Hemelytra pale, with conspicuous dark spots or cloudings. .var. **colon** Say.
  BB. Hemelytra practically unicolorous pale................var. **castus** n. var.
AA. Hemelytra entirely dark (reddish-brown to blackish-fuscous) or with markings lighter than ground color.
  C. Thorax varying from reddish to fuscous or fuscous clouded or vittate; thorax usually, and hemelytra always more or less spotted with pale yellow....................................var. **colonus** n. var.
  CC. Thorax as in last variety; hemelytra almost or entirely lacking yellow spots......................................var. **amiculus** n. var.

Paracalocoris colon var. **colon** Say (Loc. cit.)

Length 7 mm.; length of thorax 1.46 mm.; width of thorax: front .83 mm.; back 2.2 mm.; length of antennal joints: first 1.2 mm., second 2.13 mm., third .86 mm., fourth .7 mm.

Ground color stramineous to testaceous; plentifully pilose with short white to golden hairs.

Head with faintly indicated herring bone pattern, interrupted along median line, sometimes with dusky clouding above. Antennæ testaceous, the basal joint somewhat reddish; narrow annulus at base and apical third of second joint, piceous; third and fourth each darker toward apex.

Thorax with following fuscous markings: spots near anterior angles or transverse band behind stricture, widening vittæ from discal spots to posterior margin, and vittæ along lateral margin outside of former pair, the two sometimes merged.

Scutellum with fuscous mark near base and indications at least of narrow median pale vitta. Clavus within, irregular blotches on corium near clavus, on middle of costal part of corium, apex of corium and apex of cuneus, fuscous. Membrane vitreous with fuscous clouding. Lower surface variegated with ground color and fuscous, the latter covering most of the genital segment and under surface of thorax. Legs with pale fuscous to fusco-piceous irrorations near apices of all femora and near bases of hind femora; traces at least of two dark and three light annuli on tibiæ; tarsi dark apically.

Staten Id., N. Y., June 17, 1 ♂ (H.) and 1 ♀ (D.), Wm. T. Davis.

Paracalocoris colon var. **castus** n. var.

Length 5.5-7 mm.; length of thorax 1.5-1.6 mm.; width of thorax: front .8-.9 mm.; back 1.5-1.6 mm.; length of antennal joints: first .83-1 mm.; second 1.93-2.06 mm.; third .8 mm.; fourth 1 mm.

The color varies from sordid stramineous to light reddish-brown. There are no distinct markings on head or body above besides discal spots on thorax and dusky to piceous spots on apex of corium and dusky or clouded membrane. The cuneus varies from stramineous spotted with reddish-yellow to clear reddish. Antennæ as in typical variety sometimes paler, last joint sometimes almost wholly fusco-piceous. Legs and under surface as in typical variety but lighter.

Beltsville, Md., July 4, 1915. On Psedera quinquefolia, W. L. McAtee, 1 ♀, (type), (M.).

Haverstraw, N. Y., July 4, 1897, 1 ♀, (N. M.).

Staten Id., N. Y., August 17, W. T. Davis, 1 ♂, (D.).

Beltsville, Md., June 14, 1914, 1 ♀, W. L. McAtee, same date as type, 4 ♀, 1 ♂, W. L. McAtee, (M.).

Washington, D. C., June 23, 1905, 1 ♂, 1 ♀, O. Heidemann (H.).

Illegible locality, 2 ♀, (N. M.).

Paracalocoris colon var. **colonus** n. var.

Length 5.5-7 mm.; length of thorax 1.1-1.4 mm., width of thorax: front .76-.96 mm.; back 1.76-2.1 mm.; length of antennal joints: first .93-1 mm.; second 2.06-2.2 mm., third .8-.806 mm.; fourth .903-1 mm.

Head testaceous, with usual herring bone pattern and some blotches, pale fuscous to fuscous; eyes reddish testaceous, blotched or clouded with same color. Antennæ about as in typical variety, first joint in particular sometimes darker. In distinctly marked forms first joint may be yellowish spotted, and pale yellowish part of second joint broken by a wide pale fuscous band.

Thorax red-brown to fusco-piceous or with clouding or more definite transverse marking behind apical stricture, and broad vittæ from discal spots to hind margin fuscous or fusco-piceous. Area laterad of these vittæ sometimes also of same color. Areas in front of and sometimes surrounding discal spots, spots along median line and often elsewhere, yellowish-testaceous.

Scutellum fuscous to fusco-piceous, usually with median vitta or traces of it at least apically, extreme apex, and submarginal vittæ or traces thereof pale yellowish.

Hemelytra reddish-brown to fusco-piceous with scattered pale yellowish spots (tending to be longitudinally elongate), especially numerous near and in cuneus. In extreme forms these agglomerated into patches along cubitus; clavus usually only slightly marked. Cuneus more reddish than any other part of hemelytra. Membrane vitreous with fuscous clouding to almost black; apex of corium fuscous to fusco-piceous.

Legs more heavily marked than in preceding varieties; femora irrorate with or largely reddish to fusco-piceous, spotted with yellowish; tibiæ also yellow spotted and tending to have two dark and two pale annuli; tarsi darker toward tips. Under surface variegated with yellowish and fuscous; three dark and two light bands on side of head, under side pale fuscous; sides of prothorax with 2 narrow pale bands, each bordered on both sides by darker color, the lower at least represented by a distinct yellowish, fuscous-bordered spot, above insertion of front leg; a pale vitta across side of meso- and meta-thorax, and a series of about three dark and three pale bands on sides of abdominal segments. These markings may be traced in dark specimens of the other varieties of colon.

Rather a heterogenous assemblage, but on account of overlapping variations not easily divisible into smaller groups.

Well-marked dark specimens of this variety answer well to the description of *Paracalocoris attenuatus Distant**, but in the absence of authentic specimens of that form, it is preferable to use a different name. If the two forms are later found to be identical, the fact can easily be indicated.

Bluemont, Va., July 1, 1914, W. L. McAtee, 1♂ (Type) (M.).

Middlebury, Vt., July, 1912, 1♂, (K.).

Haverstraw, N. Y., July 4, 1897, 3♂, (N. M.).

Lancaster, N. Y., August, 1886, 1♀, (N. M.).

Greensburg, Pa., July 25, 1 ♀, M. Wirtner, (H.).

Lake Hopatcong, N. J., July 4, 1913, 1♀, W. T. Davis, (K.).

Trenton, N. J., 2♂, (H.).

Beltsville, Md., June 14, 1914, 2♂, July 4, 1915, on Psedera quinquefolia, 1♂, W. L. McAtee, (M.).

Bluemont, Va., July 1, 1914, W. L. McAtee, 2♂, (M.).

Paris, Fauquier Co., Va., July 27, 1890, on wild grape, O. Heidemann, 1♀, (H.).

Missouri, C. V. Riley, 1♀, (N. M.).

Ft. Collins, Colo., July 21, 1899, E. D. Ball, 3♀, 2♂, (N. M., H.).

Paracalocoris colon var. **amiculus** n. var.

Similar to last, but hemelytra almost or entirely lacking yellowish spots. Cuneus reddish, usually more or less yellowish spotted, membrane and apex of corium dusky to black. Legs and antennæ darker than in last variety.

Beltsville, Md., July 4, 1915. On Psedera quinquefolia, W. L. McAtee, 1♂, (Type) (M.). Same data, 1♀, (M.).

Plummers Id., Md., June 17, 1906, W. L. McAtee, 1♂, (M.).

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*Biologia Centrali-Americana. Insecta, Rhynchota, Hemiptera-Heteroptera, Vol. I, p. 264, Feb., 1884 (San Geronimo, Gautemala; Bugaba, Panama).

Paracalocoris heidemanni Reuter.

Paracalocoris heidemanni Reuter, O. M. Bemerkungen uber nearktische Capsiden nebst beschreibung neuer Arten. Acta Societatis Scientearum Fennicae, 36, No. 2, 1909, p. 40. (Aurora, W. Va., August 19, 1904,* O. Heidemann).

Length 6-7 mm.; length of thorax 1.23-1.3 mm.; width of thorax: front .66-.73 mm.; back 1.8-193 mm.; length of antennal joints: first 1-1.16 mm., second 1.93-2.06 mm., third .9-.93 mm., fourth .96-1.06 mm.

Range: The known range comprises only Maryland, Virginia and West Virginia.

Two color varieties may be distinguished as follows:

A. Vitta overlying cubital vein contrasting decidedly in color with adjacent parts of corium.................................var. *heidemanni* Reuter.
AA. Corium practically uniform in color..................var. *ablutus* n. var.

Paracalocoris heidemanni var. **heidemanni** Reuter. (Loc. cit.)

The form described below must be regarded as the typical variety, although Reuter's description of the ground color of hemelytra as fusco-testaceous or isabelline, by no means suggests the rich mahogany-red color of most of the specimens.

Fully colored specimens are as follows: Head reddish testaceous, with herring bone pattern on vertex in a darker red brown; eyes piceous. Antennæ dark red-brown, first joint sprinkled with yellow, and as a whole with the following piceous markings: Extreme apex of first joint, narrow basal annulus and apical half of second; apical 4-5 of third and fourth joints.

Ground color of upper parts a rich mahogany red, deepest on corium, with the following yellow or golden markings; thorax anterior to apical stricture, a median vitta and two others just outside discal spots extending to and broadening at posterior margin of thorax; narrow median and broader marginal vittæ on scutellum; streak on corium, bordering basal half of clavus, clavus along commissure, vitta along cubitus to apex of corium, narrow costal margin and sometimes a small isolated spot at center of apical margin of corium. Cuneus somewhat deeper in hue than ground color of corium. Membrane dusky, with paler areas and pale reddish vein. Legs pale reddish, femora yellow spotted. Under surface marked with yellow and mahogany red; a series of two dark and three light stripes along side of thorax and about three dark and four light, interrupted vittæ on sides of body segments.

In the paler specimens that may be said to have cubital vittæ, the ground color is yellow-brown to which the cuneus retaining its reddish cast is in distinct contrast.

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*Should be August 16.

Plummers Island, Md., July 19, 26 and August 9, 1914. On Hypericum prolificum. Numerous specimens. W. L. McAtee, (M.). August 4 and 11, 1907, 1 ♀, 1 ♂, W. L. McAtee (H.).

Bladensburg, Md., July 6, 1906, 1 ♂, O. Heidemann, (H.).

Casanova, Va., August, 1912, 1 ♂, O. Heidemann, (H.).

Aurora, W. Va., August 22, 1904, 1 ♀, O Heidemann, (H.).

Paracalocoris heidemanni var. **ablutus** n. var.

This differs from the typical variety chiefly in the general paleness of the ground color, which so approximates that of the vittæ that the latter are scarcely or not distinguishable, especially those on hemelytra. The scutellar and thoracic markings usually are evident. The cuneus is paler than in typical form though still in contrast (pale reddish-brown) to ground color (light orange-yellow). Upper surface with abundant golden hairs as in typical variety. Vein of membrane whitish.

Plummers Island, Md., July 14, 1915. On Hypericum prolificum. 1 ♂, Type, W. L. McAtee (M.). Other specimens from same locality and date; also July 19 and 26. (M.)

Bladensburg, Md., July 6, 1906, 1 ♀, O Heidemann, (H.).

Casanova, Va., August, 1912, 1 ♀, O. Heidemann, (H.).

Hypericum prolificum L. is the true food plant of *Paracalocoris heidemanni* in the vicinity of Washington, D. C., for upon it the nymphs are reared. Occurrence of the species is practically restricted to the flowering season of the p.ant.

The nymphs in my possession may be described as follows:

Total length 4 mm.; length of thorax, .86 mm., width of thorax, front .83 mm., back 1.6 mm.; distance from back of thorax to tip of wing pad 1.53 mm.; length of antennal joints, first .83 mm., second 1.46 mm., third .83 mm., fourth .8 mm.

Head and thorax sordid testaceous irrorated with reddish. First two joints of antenna rufo-fuscous with abundant coarse black pile. (Only the first joint is so haired in adult). First joint sometimes dotted with yellowish. Third fuscous, pale reddish at base; fourth testaceous to fuscous. Wing-pads sordid rufo-testaceous, these and remainder of upper surface with numerous soft white hairs. Dorsum of abdomen either reddish with a row of yellow dots across each segment, or yellowish with red dots. Legs reddish to fuscous, femora spotted with yellowish. Under surface reddish with yellow spots or the reverse.

Plummers Island, Md., July 14 and 19, 1915. W. L. McAtee, (M.).

Paracalocoris multisignatus Reuter.

Paracalocoris multisignatus. Reuter. Acta Soc. Sci. Fennicæ, 36, No. 2, 1909, pp. 40-41 (Rock Creek, D. C., June 29, 1890, and Washington, D. C., June 22,* 1905. O. Heidemann).

Length 6-7 mm.; length of thorax 1.1-1.33 mm.; width of thorax, front, .56-.66 mm., back 1.63-1.93 mm.; length of antennal joints: first .93-1.06 mm., second 1.86-1.93 mm., third .9-.96 mm., fourth .9-? mm.

A specimen with the markings fully developed has the head reddish cream color, and the eyes stramineous flecked with piceous. The first joint of antenna is fuscous, pale at base; the second stramineous, with a reddish-cream annulus on second quarter from base and the apical quarter fusco-piceous; the last two joints have similar though more obscure markings.

Front and hind margins of thorax, vittæ from latter to discal spots, and band between these pale fuscous, interrupted by small amber yellow spots; leaving three large areas of amber yellow, one on each side extending down over side of thorax and a median sub-basal area.

A large amber yellow spot covers apical third of scutellum; a large spot of same color on cuneus, another just anterior to cuneus and a third midway between this and base of corium. Apex of clavus also amber yellow. Ground color between these areas pale fuscous to blackish brown, with small amber yellow spots. Membrane fumose with paler areas. Legs pale yellow, distal halves or less of femora, two annuli on tibiæ, and tips of tarsi fuscous. Undersurface amber yellow, with fuscous markings on sides of meso- and meta-thoraces, body segments near lateral margins, on middle of subgenital and edge of genital segments.

Principal variations in color are: First joint of antenna may be only fuscous spotted; large amber yellow spots may be obscured either by themselves becoming darker or the ground color paling so as to be almost as pale as the spots. Under surface sometimes wholly pale yellow.

Beltsville, Md., June 14, 1914, 1 ♀, July 4, 1915. On Psedera quinquefolia. 1 ♂, 2 ♀. W. L. McAtee, (M.).

Washington, D. C., June 7, 1884, 1 ♀, O Heidemann, (N. M.).

Hampton, Va., July, (K.).

Texas, 1 ♂, (N. M.).

Paracalocoris jurgiosus Stal.

Calocoris jurgiosus Stal. Hemiptera mexicana enumeravit speciesque novas descripsit. Entomologische Zeitung (Stettin). Jahrg. 23, No. 7-9, July-Sept. 1862, p. 320 (Mexico).

Length 4.5-6.5 mm.; length of thorax 1.16-1.6 mm.; width of thorax: front .66-.73 mm., back 1.73-1.93 mm.; length of antennal joints: first .8-.93 mm., second 1.73-1.83 mm., third .7-.76 mm., fourth .7-.76 mm.

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*Should be June 23.

This insect, while furnished with a considerable number of hairs on upper surface, particularly of corium, has a more polished appearance than usual in the genus. The smooth, shiny surface of head, thorax and scutellum is especially noticeable.

Head shining stramineous to reddish testaceous, herring bone pattern faintly indicated. Antennæ reddish testaceous, with following markings: First joint with yellowish spots; second with narrow annulus at base fuscous, one of equal width above it whitish, then about one-third of length of joint of ground color, followed by another narrow whitish annulus, the remainder (nearly half) of joint fusco-piceous; third and fourth joints tipped with fusco-piceous.

The ground color of thorax varies from reddish testaceous to fusco-piceous and the markings from stramineous to amber-yellow. The pattern of markings is as follows: Front margin of thorax a patch between discal spots, and one outside each of them, usually extending as vittæ toward posterior margin of thorax and narrow posterior margin of thorax; on scutellum a narrow median and two broader submarginal vittæ, sometimes broken into dots; on clavus a vitta each side of claval vein; on corium narrow costal margin, vittæ along costal cubital and brachial veins and one paralleling clavus, all usually more or less broken: cuneus with an irregular patch and two longitudinal vittæ. Membrane vitreous to dusky, usually with more hyaline areas and vein in part pale.

Under surface with same colors as upper, a series of 3-5 dark and 3-4 light markings along sides of abdomen; segments pale along posterior margins; a pale vitta underlined by a narrow dark one at top of lateral aspect of pronotum. Legs with same colors, femora banded at middle and sprinkled elsewhere with paler; anterior two pairs of tibiæ dark on basal third, pale elsewhere; posterior or tibiæ with two dark and two pale bands; tarsi fuscous apically.

Brownsville, Texas, June 6, 1895, E. A. Schwarz, 1 ♀.

Brownsville, Texas, June 1, 1907, on cotton. R. A. Cushman, 1 ♀.

San Antonio, Texas, April 18, 1908, W. D. Hunter & F. C. Pratt, 2 ♂, 2 ♀.

Sabinal, Texas, May 26, 1910, F. C. Pratt, 1 ♀.

Hondo, Texas, June 3, 1909, J. D. Mitchell, 1 ♀.

Neuces River, Zanalla Co., Texas, April 29, W. D. Hunter and F. C. Pratt, 1 ♀.

Gregory, Texas, May 30, 1910, W. D. Pierce, 1 ♀.

Devil's River, Texas, May 5, 1907. On sumach, F. C. Bishopp, 1 ♂.

Kennedy, Texas, April 5, 1896. C. L. Marlatt, 1 ♀.

Another specimen from San Diego, Texas, April 25, E. A. Schwarz in teneral condition, possibly is this species. All of the above are in the National Museum collection.

Paracalocoris acceptus n. sp.

Length 6 mm.; length of thorax 1.26 mm.; width of thorax: front .53 mm., back 1.46 mm.; length of antennal joints: first 1.16 mm., second 2.4 mm., third .96 mm., fourth .86 mm.

Head cream color, eyes straw blotched with piceous; first antennal joint blotched with piceous and cream, second fusco-piceous with indistinct cream annulus a little nearer base than apex, third and fourth joints paler, each with a pale ring at base. Pilosity piceous on first joint, fading to white on terminal joints.

Anterior part of thorax and cuneus pale cream color, ground color of remainder of upper surface stramineous, sparsely irrorate with fuscous, the irrorations on thorax and about cuneus varying to fusco-piceous. A complete longitudinal line of this color just below lateral margin of thorax, and one traversing anterior half of thorax just above the margin. Hemelytra lightly margined with fusco-piceous. Membrane fumose, with paler areas paralleling the vein.

Legs stramineous; femora irrorate with fuscous; tibiæ irrorate, but the markings tending to be grouped in four dark annuli, bounding three pale ones; tarsi stramineous basally, fuscous apically.

Under surface stramineous varying to cream, an indistinct fuscous markings across sides of meso- and meta-thorax above coxæ.

Camping place about 3 miles south of San Augustine Ranch, east side of Organ Mountains, New Mexico, August 28, 1894. At light. 1 ♂ Type, T. D. A. Cockerell (H.). Full data kindly furnished by Professor Cockerell.

Paracalocoris deleticus Reuter.

Paracalocoris deleticus Reuter. Uhler ms. Nearktische Capsiden. Acta Soc. Sci. Fennicæ, 36, No. 2, 1909, p. 40. (Lamar, Colo., October 9, 1898, Van Duzee).

Length 6.5-7.5 mm.; length of thorax 1.6-1.66 mm.; width of thorax: front .9-1 mm., back 2.3-2.5 mm.; length of antennal joints: first 1.2-1.23 mm., second 2.3-2.4 mm., third 1-1.06 mm., fourth .83-1.06 mm.

Upper surface polished, with few hairs, except hemelytra, which have numerous inconspicuous short hairs. Ground color stramineous to cream color; herring bone pattern very faintly indicated on head, eyes piceous. Antennæ rufo-testaceous, a little tinged with fuscous near tips of last three joints; last two joints paler near base.

Thorax with faint fuscous to fusco-piceous irrorations near hind margin. Scutellum with one or two faint patches of same color near base. One specimen has a faint orange red patch each side of median line of scutellum near base. Fuscous to fusco-piceous vittæ dotted with ground color, located as follows on hemelytra: One on clavus, and two on corium over the terminal portions of cubital and brachial veins. Faint fuscous clouding along suture between clavus and corium and sometimes elsewhere. Cuneus orange red. Membrane hyaline with faint dusky clouding.

Femora slightly sprinkled or irrorate with usually dark color toward apices; tibiæ slightly dotted, and tarsi darker apically. Scattered dark points or dashes along sides of thorax and abdominal segments.

Clarendon, Texas, September 19, 1905. On sagebrush (Artemisia filifolia). W. D. Pierce, 1 ♂, 2 ♀.

Mesilla, N. Mex., June 15, on flowerhead of Dalea lanosa (Parosela lanata?), T. D. A. Cockerell. 1 ♀. All in National Museum collection.

THE MALPIGHIAN VESSELS OF HALTICA BIMARGINATA SAY (COLEOPTERA).

By William Colcord Woods.*

1. The general structure of the larval vessels.
2. The general structure of the vessels of the imago.
3. A comparison of the conditions in *Haltica bimarginata* with those described for certain other Coleoptera.
4. The function of that portion of the tubes associated with the wall of the colon.

1. THE GENERAL STRUCTURE OF THE LARVAL VESSELS.

INTRODUCTION.

In connection with a study of the internal metamorphosis of the alder flea beetle, *Haltica bimarginata* Say (Chrysomelidæ), a problem which has been occupying the attention of the writer for some months past, observations have been made on the number and arrangement of the Malpighian vessels in these insects. Some striking features were brought out, which seemed worthy of special mention.

THE ALIMENTARY CANAL OF THE LARVA.

In the alimentary canal of the larva of the alder flea beetle, the three primary divisions, fore-intestine, mid-intestine, and hind-intestine can be made out readily. The fore-intestine consists of a short pharynx, a short oesophagus, and a short, thin-walled distensible crop. The mid-intestine, which forms by far the greater part of the canal, is divided into two regions, separated exteriorly by a constriction, each region having a distinct type of epithelium peculiar to it. The hind-intestine consists of three short regions, a small intestine or ileum, a large intestine or colon, and a very muscular rectum. The distinction between these parts is clear as well in dissected specimens as in sectioned material.

Figure 1, a diagram of the alimentary canal, shows the relationship of these parts, although the intestine is actually more convoluted and the folds overlie one another to a greater extent than is there indicated.

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*Contribution from the Entomological Laboratory of Cornell University.

THE MALPIGHIAN VESSELS.

From a morphological point of view, the Malpighian vessels of an insect are ectodermal structures, which arise during embryonic life as evaginations of the distal end of the hind-intestine (which is itself an invagination of the ectoderm). In a typical insect, the Malpighian vessels empty into the alimentary canal at the junction of the mid-intestine with the hind-intestine, and after a greater or less course end blindly in the body cavity.

In the larva of *Haltica bimarginata* the arrangement is very characteristic and presents some interesting and rather unusual features. In this insect there are six Malpighian vessels, which are morphologically divisible into two series, differing from one another in point of origin, in length, in macroscopic aspect, and in microscopic structure.

Such a dimorphism in the tubes of the same individual is by no means confined to *Haltica*, but has already been reported for numerous Coleoptera. Indeed, much greater dimorphism has been described for many insects, and while most of the instances cited have been discredited by later workers, it is generally admitted that there is a very decided dimorphism, correlated with a difference in function, in the Malpighian vessels of *Stratiomyia* (Vaney, 1900) and of phasmids (Sinety, 1900).

In *Haltica*, the first series is composed of four vessels which unite at their bases, forming what is generally termed, from analogy with the vertebrates, an urinary bladder. This small ovoid bladder empties directly into the hind intestine, shortly behind its union with the mesenteron. (This condition is illustrated in Figures 1 and 5). At the point of junction of the mid-intestine and the hind-intestine there is a sharp bend, and between the mesenteron which runs caudad and the ileum which extends cephalad, is formed a strong angle, on the inner side of which the bladder opens directly into the lumen of the intestine.

The four vessels leave this bladder in a parallel series so that there are two outer vessels and two inner. These tubes, which are more or less imbedded in the adipose tissue, are long and somewhat twisted, so that it is difficult to trace their course especially as they are easily broken. They are closely apposed to the alimentary canal throughout most of their extent, but are always entirely distinct from its walls (except in the colon at their distal ends, as will be explained later). Following very closely the course of the mid-intestine and appressed to its walls, they extend forward as far as the beginning of the crop (i. e., into the mesothorax). Here they bend back on themselves and extend nearly to the posterior end of the body. In a typical cross-section through the meso- or metathorax and the first five abdominal segments, therefore, the mid-intestine is surrounded by eight sections of the Malpighian vessels quite regularly arranged, so that one would naturally interpret them as eight distinct vessels if he did not know the true circumstances of the case. At the constriction between the two parts of the mid-intestine, the Malpighian vessels cease to be associated with the walls of the alimentary canal, and then run posteriorly in the fat body as far as the eighth abdominal segment, where they again double back on themselves, and run cephalad to the sixth abdominal segment. Here they pass into the walls of the colon in a manner that will presently be described.

There is a great deal of variation in the length and course of these tubes, and the condition described above is to be regarded as the average condition rather than an exact description of the distribution of the tubes as found in any one individual specimen. Sometimes the vessels are much convoluted, at other times they seem to be nearly straight; in some cases they follow closely the windings of the second division of the mid-intestine in their course cephalad, and at other times they do not; often they do not quite reach the anterior end of the mesenteron and rarely they may even extend a little beyond into the prothorax. But the diameter of the vessels and their color, a dull opaque white, are constant characters in this series.

The second series of vessels arises independently of the first, and some little distance in front. It consists of two isolated Malpighian vessels which enter the alimentary canal at the exact point where the mid-intestinal epithelium ends. Sections through the evagination of these tubes show typical mid-intestinal epithelium, but the sections immediately succeeding show the beginning of the hind-intestinal epithelium. These two vessels leave the intestine side by side, and very close together, but are entirely independent of one another. It should not be inferred from any of the above statements that the writer regards the second series of tubes as appendages of the mid-intestine. The epithelium of that portion of the ileum into which both series of vessels empty is strikingly different from that of the remainder of this division of the intestine, and the cells of the Malpighian vessels are very different from those of the mid-intestine. The second series of vessels, as well as the first, belongs to the hind-intestine.

The two vessels which constitute the second series are very much shorter than the four tubes of the first series. They extend only a short distance anteriorly, usually following the twisting of the mesenteron, and then run more or less directly to the junction of the ileum and colon. Under the binocular these vessels appear more delicate than those of the first series, the diameter is slightly less, the cells are slightly smaller, and in color they are more or less a translucent white, instead of being opaque.

Thus far we have traced the course of the four vessels of the first series and the two vessels of the second series, and have seen that all six finally extend to the vicinity of the strong bend caudad in the alimentary canal, which marks externally the end of the ileum and the beginning of the colon.

The four vessels of the first series, which represent two pairs, at the distal ends of their coelomic portions unite into two common stems, consisting of two vessels each. One of the short vessels of the second series soon becomes closely associated with each stem, and thus all six of the tubes have now been accounted for. Each stem with its apposed vessel applies itself closely to the wall of the colon, one on the dorsal side and one on the ventral. Up to this point the vessels of the second series remain distinct, but here each fuses with the stem with which it is associated, and thus two common trunks, representing three vessels each, are formed, one lying on the dorsal wall of the colon and one on the ventral wall.

In *Haltica bimarginata* the colon consists of the following parts, passing toward the exterior: intima, epithelium, basement membrane, circular muscle layer, longitudinal muscle layer, (and later a layer of Malpighian vessels and a peritoneal layer). All of the intestinal muscles, both circular and longitudinal, are clearly striated. The circular muscles are strongly developed in all but the posterior portion of the colon; there is a single row of them forming a continuous layer around the alimentary canal. The longitudinal muscle layer consists of six large fibres, which are rather regularly disposed, outside of the circular muscles.

Each vessel trunk lies between two of these longitudinal muscle fibres. As soon as the vessels have become appressed to the wall of the colon, their peritoneal sheaths grow out and join, so that a continuous peritoneal coat is formed, completely surrounding the colon, and enclosing the six muscle fibres and the two Malpighian trunks. As soon as this tunic is complete, each of the trunks redivides into three vessels, which almost immediately begin to "migrate" outside the muscle fibres so as to lie alternately with them. This "slipping" or "migration" extends through about twenty sections of six micra each before it is completed. The condition which results characterizes the greater part of the colon and in a typical cross section, one will find lying without the circular muscles, a layer composed of the six longitudinal muscle fibres alternating with the six Malpighian vessels, the whole surrounded by a nucleated peritoneum, probably of connective tissue, which, as it represents the investing sheath of the vessels, is a double layer. The two sheets separate at the vessels, one layer passing inside and the other outside of the tubes, but both sheets pass outside of the longitudinal muscles.

Figure 2 shows the Malpighian vessels after they have separated from the trunk "migrating" outside the fibres of the longitudinal muscles. Figure 3 shows diagrammatically a typical cross section of the colon. In reality the epithelium is not a syncytium.

In the more anterior part of the colon, the cross sections of the Malpighian vessels and of the longitudinal muscles are about equal in diameter. But as one traces the sections caudad, the Malpighian vessels gradually increase in size while the muscles decrease in size, and two thirds of the way to the end of the colon this has become very marked, the Malpighian vessels here being twice as large as the muscles. At this point the longitudinal muscles begin to diminish in size rapidly and become very small, although they persist faintly to the end of the region. The circular muscles also decrease so markedly as to be almost negligible. The Malpighian vessels, which have been almost circular in cross sections, now become elongated along the diameter perpendicular to the axis of the canal, and tend to crowd the longitudinal muscles inside. This tendency becomes more and more pronounced, and some little distance before the end of the colon, the intestine is surrounded by a practically continuous layer of Malpighian tubes, with the small longitudinal muscles intercalated between them. The vessels do not extend along the wall of the rectum, but seem to terminate blindly at the posterior end of the colon.

It is very difficult to make out the exact course of the vessels in the walls of the colon in a dissected specimen. They seem to extend posteriorly as six parallel tubes, at first of slight diameter and almost straight; but, as was noted in the preceding paragraph, as the diameter increases, they become more and more wavy, with larger and larger folds. It is this character which makes the vessels appear so elongated in cross sections. Toward the end of the colon, these undulatory folds are so large that those of one series almost touch those of the adjacent series, and thus they almost completely surround the wall of the colon. The vessels seem to branch irregularly, the tubes terminating blindly and separately in irregular ramifications, just anterior to the strong circular muscles which appear abruptly, and mark externally the beginning of the rectum. The tubes in the wall of the colon have an extremely abundant tracheal supply, a fact which makes dissection difficult, and makes it much harder to trace them out.

The distribution and ramification of one of the Malpighian trunks in the wall of the colon is shown diagrammatically in Figure 4. It should be noted that the strong circular muscles which mark the beginning of the rectum are peculiar to that region, and there are no muscles overlying the Malpighian vessels in the wall of the colon.

We may summarize, then, the distribution of the Malpighian tubes in the larva of *Haltica bimarginata* as follows, beginning at their distal ends. Six Malpighian vessels extend parallel to one another, running cephalad in the wall of the colon. They unite at the anterior end of this region to form two common trunks, which leaving the wall of the intestine, split up into a single tube and a common stem representing a pair of tubes. The single tube, which is very short and delicate, runs quite directly to the mesenteron, where it is inserted isolated into the wall of the intestine, just at the point of junction between the mid-intestine and the hind-intestine. Each common stem soon splits up into two vessels which have a long course through the body cavity. Eventually the four vessels unite to form a single common urinary bladder, which empties into the hind-intestine at a point a little posterior to the insertion of the two shorter tubes. This condition is shown very diagrammatically in Figure 5.

2. THE GENERAL STRUCTURE OF THE VESSELS OF THE IMAGO.

The Malpighian vessels of the adult beetle of *Haltica bimarginata* have exactly the same relations as have just been described for the larva.

3. A COMPARISON OF THE CONDITIONS IN *Haltica bimarginata* WITH THOSE DESCRIBED FOR CERTAIN OTHER COLEOPTERA.

Not one of the general features noted above, although very different in many respects from the typical arrangement in insects, is peculiar to *Haltica bimarginata*, but all of these relations have been described for other forms, although so far as the writer is aware, there has never been a single species of insect recorded in which so many of them were illustrated.

It has long been known that the Malpighian vessels may have two apparent terminations in the intestine. In all known cases the second termination is merely superficial, in the walls of either the colon or the rectum, and the vessels do not empty into the alimentary canal except at the point of their evagination.

So far as the writer has been able to ascertain, the earliest work in which there is any reference to such a condition is Ramdohr's paper, which appeared in 1811. He figured the alimentary canals of at least 22 genera of Coleoptera, representing 10 families, 2 genera of Neuroptera, 3 genera of Hemiptera, 1 genus of Lepidoptera, and 1 genus of Diptera, in which the Malpighian vessels become reassociated with the alimentary canal at their distal ends, although he did not discuss this point at length.

The next reference is to be found in the classic work of Straus-Durckheim on a scarabaeid, *Melolontha vulgaris*, which was published in 1828.

Léon Dufour seems to have been the first man who did extended work on the Malpighian vessels of insects, and was the first author to point out the fact that the posterior intestinal insertion of the Malpighian vessels is only superficial. In discussing the metamorphosis of *Mordella fasciata* (Coleoptera) he wrote in 1840: "* * * I have always thought that this insertion penetrated the tunics of the coecum or the rectum in such a manner that the vessels might discharge a portion of their products of secretion into the interior of the latter. It is thus that all entomotomists have regarded this point of anatomy. * * * The posterior or coecal insertion of the hepatic vessels of the larva of *Mordella* (and perhaps or probably of all insects) is only superficial. These vessels instead of emptying into the intestine * * * simply ramify and are lost in a hyaline membraniform tissue which surrounds it. * * *" (Pages 231 and 232).

Dufour published a memoir on the Malpighian vessels in 1843, in which he discussed this double insertion still further, and described the conditions as he found them in several chrysomelids. In speaking of *Donacia*, he said in part: "* * * These vessels, which lack a rectal insertion, differ between themselves in size and the manner of insertion; they have * * * only a ventricular insertion, and although they appear to be six in number, there are really but four vessels. Two, much thinner and handle-like (à anses) are inserted by their four ends into an ovoid sessile body, which is a sort of gall-bladder (vésicule biliaire); two others, shorter, larger, swollen, large-bellied (ventrus) in the middle and floating at one end, are implanted isolated at the extremity of the ventriculus on its superior face." (Page 156). In *Crioceris merdigera*, "* * * the rectal insertion takes place by two trunks of two branches, and by two isolated vessels; and the ventricular, first by a lateral gall bladder as in *Donacia*, which receives four vessels, and then by two other more delicate vessels, colorless and isolated." (Page 157). "In *Cassida* the four principal vessels are grouped, but not confluent for their ventricular insertion; this takes place in the ventral wall of that organ; the thinner vessels are separately inserted. The fixation at the rectum is made by two trunks of three vessels as in the longicorns." (Page 157). "*Galeruca tanaceti* * * * have the four principal vessels inserted on the ventriculus by a single very short stump (souche) which does not deserve to be called a gall bladder, and fixed on the rectum by two well distinct trunks. The thin walled vessels have isolated insertions." (Page 158). On the same page the conditions are described for *G. lusitanica*, the only difference being that here the ventricular insertion of the four tubes of the first series is not by a bladder, but separately.

In a general way the conditions in *Haltica* agree with those described by Dufour. His generalization (page 154) that in tetramerous Coleoptera the posterior insertion is never unicauline (by one trunk) as in the great majority of the heteromerous, but is bicauline (by two trunks) or fasciculated, holds true for *bimarginata*, in which the bicauline condition exists. In *Crioceris*, in *Cassida*, and in *Galeruca* there are two series of vessels, a series of four large tubes, and a series of two smaller more delicate vessels, just as is the case in the alder flea beetle. In *Donacia* also, the two series of tubes can be recognized. In most cases the four vessels of the first series empty through a bladder (an urinary bladder of course and not a gall bladder) and there is a colonic insertion of the tubes as occurs in *Haltica bimarginata*. (Although Dufour always speaks of a rectal insertion of the vessels, he used this term loosely; and in reality all of his figures show the Malpighian vessels passing very clearly into the wall of the colon, or second division of the hind intestine, and not into the rectum, or third division.) In nearly every case which he figured, the vessels of the second series are isolated in their ventricular insertion.

The greatest differences appear when *Haltica bimarginata* is compared with *Donacia*. In both cases there are two series of vessels, the first series comprising four tubes, emptying into the alimentary canal by a common bladder, and the second comprising two shorter vessels with isolated insertions. In the latter insect, the four vessels of the first series unite at their distal ends, and it is for this reason that Dufour regarded them as really only two vessels, and referred to them as handle-like (vaisseaux à anses). The fusion of the vessels into two common stems in the alder flea beetle is probably homologous with this fusion into two pairs in *Donacia*. In *Haltica*, these vessels enter the colon wall and terminate blindly there, whereas in *Donacia*, they are fused into two pairs which lie free in the body cavity throughout their extent, and they have no free distal ending.

The vessels of the second series also present a very marked contrast in the two forms, the only point of similarity being that in both species they are shorter than the first series, and have isolated insertions. But whereas they are slender and delicate in *Haltica*, they are large and swollen in *Donacia*, much larger than the tubes of the first series, a very unusual condition which has been reported for no other chrysomelid genus. The distal ends of the vessels lie in the wall of the colon *Haltica*, and free in the body cavity in *Donacia*.

In *Crioceris* the conditions are almost identical with the alder flea beetle, in so far as Dufour has described them. In *Cassida*, the ventricular insertion is very different, but the superficial distal insertion is very suggestive of the condition in *H. bimarginata*.

Although Dufour was the first to state the probability that the posterior insertion of the vessels is merely superficial in all cases, he does not appear to have been fully convinced that this was true, especially in *Myrmeleon formicarium*. It remained for Sirodot in 1858, who summarized the results of earlier workers in a very satisfactory way, to demonstrate that in all cases, not excepting *Myrmeleon*, the posterior insertion is absolutely superficial, the vessels simply ramifying in the wall of the canal. His final statement in regard to the matter was: "As a general conclusion, then, the extremities of the Malpighian tubes are either free or united in bundles, but always without any alteration of the independence of their lumen." (Page 261).

Schindler's paper in 1878 was the next important contribution to our knowledge of the Malpighian vessels. Summarizing the results of his own studies on Coleoptera and those of preceding writers, he said: "Where one finds six vessels, it is often the case that they unite with one another at their extremities into one or two apparently common stalks, and seem to empty into the rectum, which is however, never the case, for after the common stalk has penetrated the outer layer of the canal, the vessels again separate and bury themselves, ending blindly beneath this coat." (Page 630).

Schindler also recorded the condition of the vessels in *Haltica nemorum*. "Léon Dufour has already pointed out that in *Donacia* two pairs of winding 'gall-vessels' empty into a single 'gall-bladder' on the side of the stomach, while two other isolated canals are inserted in the under part of the stomach. A very similar condition is demonstrable in *Haltica nemorum*. Here the first four urinary tubes—in this case blind-ended—empty into a pyriform bladder. The bladder, which is only a urinary bladder and not a gall bladder, measures 1.0 mm. in cross section, and empties through a stalk (Stiel), the urethra, almost 1.5 mm. long, into the upper end of the large intestine (Mastdarm). * * * Shortly above this insertion two more urinary tubes empty isolated into the pylorus." (Page 631).

While this account agrees in a general way with the condition of the tubes in *Haltica bimarginata*, it is very surprising to find such great differences in species belonging to the same genus. The bladder of *bimarginata* is proportionately smaller, and there is no stalk at all. Admittedly this is a minor character; but the fact that the vessels end distally in the wall of the colon in the one species and blindly in the body cavity in the other, is remarkable. Schindler makes no statement in regard to the comparative length of the two series of vessels in *nemorum*, and as he has evidently used the terms "large intestine" and "pylorus" loosely, it is impossible from his description to make an accurate comparison of the ventricular insertion in the two species.

In 1910 Poyarkoff published an article dealing with the metamorphosis of another chrysomelid, *Galerucella luteola*, in which he described the larval vessels. According to his statement, they are four in number and empty into the second division of the hind intestine at the end of a comparatively long coecum. (He recognizes four regions in the hind-intestine). These four vessels after a long course through the body pass into the wall of the colon, where two of them bifurcate, so that there are six vessels associated with this portion of the intestine (the third region). (Pages 337, 401-402 and 414).

The condition described above is entirely different from that in *Haltica bimarginata*, save that in the latter also there are six vessels associated with the wall of the colon. However, the distribution of these vessels in the colon wall of *Galerucella*, according to Poyarkoff, is very similar to the alder flea beetle. In *Galerucella* they are at first small, and then they become larger, ramifying irregularly so as to form an almost complete layer around the canal. In his figures, the peritoneal envelope is shown passing around the Malpighian vessels and outside the longitudinal muscles, just as has been described above for *Haltica bimarginata*.

The most recent paper dealing with the general subject of Malpighian tubes is the valuable contribution of Gorka in 1914. He studied two genera of Coleoptera, *Gnaptor* (family Tenebrionidæ) and *Necrophorus* (family Silphidæ). In his general summary may be found the following conclusions: "The number of Malpighian vessels is six in *Gnaptor spinimanus* and four in *Necrophorus humator*. In *Gnaptor* the Malpighian vessels build a network on the walls of the rectum, yet without emptying into it. Out of this network, which is due to the union of the vessels in pairs after a long wavy course on the walls of the rectum, a single thick stem is formed. This stem does not represent a fusion of the Malpighian vessels, but only a very close apposition. The common stem then divides into two branches, each of which consists of three vessels. Finally these also separate out and empty after a short course through the body cavity into the intestine, at the boundary of the mid-intestine and the hind-intestine. The Malpighian vessels of *Necrophorus* end blindly. In all the beetles studied the Malpighian vessels empty into the mid-intestine, and not into the hind-intestine. A few epithelial cells follow behind the insertion of the Malpighian vessels in *Gnaptor*, which agree with the epithelial cells of the mid-intestine in every respect." (Pages 330 and 331).

Only in a very general way does this recall the condition in *Haltica bimarginata*. In the latter the vessels do actually fuse, and the two common trunks represent a real coalescence, not simply a close apposition of the tubes. There is no indication that the trunk is composed of three distinct vessels, but in cross sections it appears like an ordinary Malpighian tube, and is not of an appreciably greater diameter. In *Cassida*, as figured by Dufour (Ann. de. sci. nat. 1825, ser. 1, t. 4, pl. 8, fig. 1) one would also infer that there was a fusion of the three vessels and not simply an apposition. However, Gorka states that under high magnification, even without sectioning it can be seen in *Gnaptor* that the fusion is only apparent and not real.

In *H. bimarginata* there is a bladder and a dimorphism of the vessels correlated with a difference in their insertion and in their length, features no one of which is found in *Gnaptor*. Finally it is very clear in *Haltica* that the vessels pass into the wall of the colon, while from the figures of *Gnaptor* it seems equally clear that it is actually the wall of the rectum into which the vessels penetrate. It is evidently the colon into which the Malpighian tubes pass in all of the figures of chrysomelid alimentary canals drawn by Ramdohr (1811) and Dufour (1823-25, 1840, 1843).

Moreover the vessels of the alder flea beetle are very clearly appendages of the hind intestine and not of the mid-intestine. One would need very conclusive embryological data to be convinced that the Malpighian vessels were really appendages of the mid-intestine and not merely associated with it secondarily.

4. THE FUNCTION OF THAT PORTION OF THE TUBES ASSOCIATED WITH THE WALL OF THE COLON.

While working on the larvæ of *Galleria mellonella* (Lepidoptera) in 1908, Metalnikov demonstrated that the cells in the "tubes contournees" (as he termed that portion of the Malpighian vessels associated with the wall of the colon) never pass through the cyclic changes characteristic of the cells of the free portion of the vessels, and indicatory of secretory activity, nor do they take up any coloring agents injected into the body cavity. He formulated the hypothesis that this part of the tubes constitutes a special excretory apparatus which eliminates such toxic substances as may have passed through the intestinal epithelium.

This is the opinion of Poyarkoff (1910) and substantially that of Gorka (1914) who further confirmed the fact that there is a difference in the reactions and function between the portion of the tubes lying free in the body cavity and the portion associated with the hind intestine.

There seems no reason to doubt that the close association of the Malpighian vessels with the walls of the colon is for the purpose of excreting toxic products just as these authors have already pointed out. In *Haltica bimarginata* it is probable that most if not all of the digestion and absorption takes place in the mid-intestine. It also seems very likely that on account of the strong continuous layer of circular muscles the liquids absorbed do not at once pass into the body cavity, but flow backward between the basement membrane and the circular muscles. It may well be true that the greater part of this material does not pass outside the circular muscle layer until well along in the colon. Here its passage into the body cavity would be retarded by the peritoneal sheath which completely surrounds this region, and the absorbed liquids would thus be brought into close contact with the distal ends of the Malpighian vessels, which lie closely pressed against the muscle wall of the colon. Here doubtless such poisons and other harmful substances as the intestinal epithelium has allowed to pass through it are taken up by the cells of the Malpighian vessels and excreted before they have had any chance to pass into the body cavity of the insect.

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EXPLANATION OF PLATE.

FIGURE 1. The alimentary canal of the larva of *Haltica bimarginata.*

b—urinary bladder.
c—colon.
cr—crop.
i—ileum.
m_1—first division of the mid-intestine.
m_2—second division of the mid-intestine.
o—oesophagus.
p—pharynx.
r—rectum.

The walls of the alimentary canal are represented by dotted lines.

The course of the four Malpighian vessels of the first series is shown by wavy lines.

The course of the two Malpighian vessels of the second series is shown by solid lines.

FIGURE 2. Diagrammatic cross section of the colon showing the Malpighian vessels migrating around the longitudinal muscles.

i—intima.
e—epithelium.
cm—circular muscle layer.
lm—longitudinal muscle fibres.
mv—malpighian vessels associated with the colon.
pe—peritoneal envelope.

FIGURE 3. Diagrammatic cross section of the colon showing the typical alternation of Malpighian vessels and longitudinal muscles.

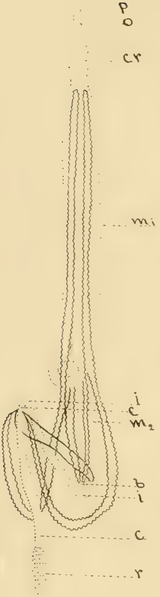
i—intima.
e—epithelium.
cm—circular muscle layer.
lm—longitudinal muscle fibres.
mv—malpighian vessels associated with the colon.
pe—peritoneal envelope.

FIGURE 4. Diagram showing the ramification of one of the Malpighian trunks in the wall of the colon.

C—colon.
R—rectum.

FIGURE 5. Scheme showing very diagrammatically the insertion and relation of the two series of Malpighian vessels.

C—colon.
I—ileum.
M—mid-intestine.
R—rectum.



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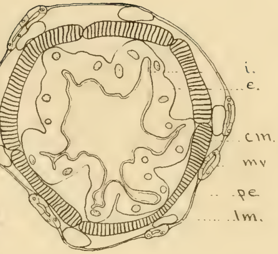

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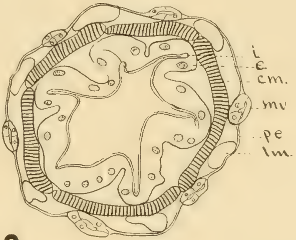

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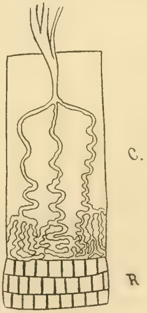

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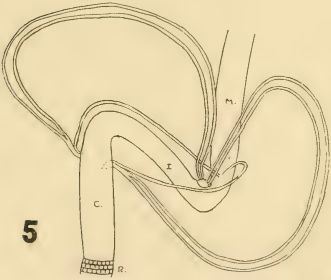

5

William C. Woods.

THE ATTRACTION OF DIPTERA TO AMMONIA.

By C. H. Richardson,
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During the course of experiments on the responses of the house-fly to certain chemical compounds, data were gathered concerning the reactions of some other species that entered the traps with more or less regularity. It is the purpose of this article to give the results of these experiments and to include brief summaries of the literature concerning the olfactory tropisms of insects.

It has long been recognized that the olfactory organs of insects are of primary importance in the search for food and for breeding places, in the assembling of the sexes, and in the reactions to certain repulsive smelling substances. The experimental study of these responses to environmental odors, neglected by entomologists in the past, has recently awakened an interest which promises important results.

Tragardh (1913) and Imms (1914) have published in England valuable resumes of the literature touching upon this subject, but I believe no fairly comprehensive bibliography has yet been placed before American students.

One of the earliest contributions to odor responses was made by Barrows (1907) on the pomace-fly, *Drosophila ampelophila* Loew. It was found that the flies responded positively to aqueous solutions of amyl alcohol, ethyl alcohol, acetic acid, lactic acid, and acetic ether. When acetic ether was added to acetic acid or ethyl alcohol, more flies were captured than when acetic acid or ethyl alcohol was used alone. A similar phenomenon was observed when isobutyl acetate or methyl acetate was mixed with ten per cent ethyl alcohol or when acetic, butyric or valerianic acid was added to ethyl alcohol. The strong mineral acids, nitric and hydrochloric, were very repellent. A solution containing two and one-half per cent. of ethyl alcohol and five-eighths per cent. of acetic acid called forth the greatest number of positive reactions. Ethyl alcohol and acetic acid are found in cider vinegar, fermented cider and California sherry in percentages close to those which induced maximum reactions in *Drosophila*. The author ascertained also that the olfactory organs in *Drosophila* which are concerned with the location of food are situated in the third or terminal segments of the antennæ. When stimulated by a weak food odor the flies responded by random movements, but as they passed into an area of greater stimulation, they became directly oriented and proceeded toward the source of the odor.

Verschaffelt (1910) has published an important paper on the compounds that determine the selection of food in larvæ of *Pieris brassicæ* and *Pieris rapæ.* These larvæ feed upon certain Cruciferæ as well as *Tropaeolium* and *Reseda*, plants which contain a group of glucosides, the mustard oils. A solution of sinigrin, one of these mustard oils, when spread upon foliage which the larvæ ordinarily refused caused them to devour it readily. The larvæ of a sawfly, *Priophorus padi*, which feed upon the leaves of certain Rosaceæ, were attracted by amygdaline, a glucoside found in these plants.

Howlett (1912) attracted fruit-flies of the genus *Dacus* to rags moistened with oil of citronella. Only the males responded to this odor and he was able to show quite conclusively that the females emit an odor closely resembling the oil of citronella. In other experiments he induced a species of *Sarcophaga* to deposit larvæ in a flask containing a solution of skatol, a compound present in the feces of many animals. He also found that *Stomoxys calcitrans* L. would oviposit on cotton-wool which had been soaked in valerianic acid and that both valerianic and butyric acids were similarly attractive to an ortalid fly of the genus *Ulidia* (?). The work was done at Pusa, India.

The same author (Howlett, 1914) demonstrated the attractiveness of benzaldehyde, cinnamylaldehyde and anisaldehyde to two undetermined species of thrips. Salicylaldehyde and isobutylaldehyde were also tried, but the results from these were not so striking. The experiments were conducted in England during the months of November and December, when thrips are not abundant. The author believes larger catches would be obtained in summer.

The Severins (1914, a and b), have studied the attractiveness of various oils to the Mediterranean Fruit-fly, *Ceratitis capitata* Wied. in the Hawaiian Islands. Kerosene was used as a bait in many experiments and it was found that most of the flies captured were males. Indeed in eight month's trapping an average of only three females was obtained in every thousand flies caught. Traps were colored white, black, blue and orange, but the size of the catches did not appear to depend on the color of the trap. Traps placed under trees whose fruits had a readily accessible supply of juice (Java plum) caught the largest number of flies, but flies were often caught in traps wired to trees not in fruit or which bore fruit not sought by the flies. Petroleum oils containing comparatively large amounts of volatile hydrocarbons were most readily sought while the heavier burning and lubricating oils were less attractive. Oil of citronella and turpentine had a very slight attraction, cocoanut oil had none. Whale and fish oils were not visited by the flies. The alluring properties of petroleum oils are probably due to one or more of the volatile hydrocarbons or to some of the impurities such as the sulphur or nitrogen constituents. While admitting that these attractive oils may give off an odor which resembles that emitted by the female fly, it is stated that the tropism may be one not associated with sex.

Chatterjee (1915) found that kusum oil from the berries of the tree, *Schleichera trijuga* attracted nymphs and adults of both sexes of a coried, *Serinetha augur*. A few drops of the oil scattered about on any suitable object was sufficient to allure large numbers of the bugs. The experiments were conducted at Dehra Dun, India.

I have recently published results of experiments on the attractiveness of ammonia and certain other chemical compounds to the house-fly *Musca domestica* L (Richardson, 1916, a. and b.). Ammonia from commercial ammonium carbonate and ammonium hydroxide was attractive to females, but was visited by few males. Eggs were deposited on the following materials when ammonium carbonate was added to them: acidulated horse manure (treated with dilute hydrochloric acid so that all the volatile ammonia was converted into the non-volatile ammonium chloride), moist timothy chaff, moist pine sawdust and moist cotton. However cotton was scarcely attractive without further addition of butyric or valerianic acid. Horse manure was the most attractive, pine sawdust and cotton the least. The house-fly apparently has some means of discriminating between substances which can and those which can not furnish food for its larvæ.

It will be noted that the activating substances where their exact chemical nature has been determined, are for the most part organic compounds, some of considerable complexity. Ammonia is the only one among these which is not a carbon compound, and it is the simplest in molecular structure.

THE EXPERIMENTS.

The flies were captured in screen wire traps nine and three-fourths inches high and six inches in diameter at the base. Pieces of commercial ammonium carbonate were placed in glass dishes in the pan of the trap and a little water was usually added to each glass dish. Ten experiments involving twenty-three traps, each containing from eighty-five to two hundred and thirty-four grams of ammonium carbonate and seventeen controls with or without water were carried out during the summer. The results, exclusive of house-flies caught are given in the following table:

TABLE A.

	Traps containing ammonium carbonate Number caught	Control traps Number caught
Phorbia sp	15	
Muscina stabulans	11	
Ravinia communis	1	2
Fannia canicularis	1	
Lucilia sericata	1	1
Ophyra leucostoma	2	
Stomoxys calcitrans	3	
Leptocera ferruginata	106	
Sepsis minuta	2	

An ortalid, *Leptocera* (*Limosina*) *ferruginata* Steub. was a frequent visitor to the traps and an undetermined *Phorbia* and *Muscina stabulans* Fall. were caught often enough to suspect they were attracted by the odor of ammonia. *Leptocera* is so small that it can pass through the meshes of the trap screen readily and only those individuals that fell into the solution were captured. Had the meshes been small enough to retain the flies which entered the traps, I believe the number would have been far larger. In the oviposition experiments with the house-fly, *Leptocera*, was almost always present, running about in the dishes containing ammoniated manure, timothy chaff and pine sawdust and even coming to those which held the ammoniated cotton. It was an abundant species in accumulations of horse manure at New Brunswick. *Sepsis minuta* Wied.

was also seen about the traps and experimental dishes frequently, but for some reason few individuals were caught. Several other species were captured in small numbers, but have not yet been identified.

Stomoxys calcitrans L. was not caught often in ammonia traps and I was not able to get it to oviposit on cotton soaked in valerianic acid, although Howlett did succeed in this at Pusa, India. Howlett does not give the details of his experiments further than to say that he used "cotton-wool soaked in valerianic acid." (Howlett, 1912, p. 416).

One trap experiment and eight oviposition experiments with valerianic acid were completed during the summer of 1915 at New Brunswick. The traps and method of using them have been described above. The oviposition experiments were performed in porcelain evaporating dishes, 120 mm. in diameter. A piece of sterilized absorbent cotton was placed in each, to the surface of which the acid and usually water were added. The experiments were carried out at various times on the window sills of a laboratory or on a bench near a livery stable. Frequent observations showed that *Stomoxys* was present in these localities throughout the course of the experiments. The results of the valerianic acid experiments are set forth in the following table:

TABLE B.

TRAP EXPERIMENT.

Amount of material.	Number of traps	Duration of experiment	Result
50 cc. valerianic acid	1	67 hrs.	No *Stomoxys*
50 cc. distilled water	1	"	"

OVIPOSITION EXPERIMENTS.

Amount of material	Number of experimental dishes	Duration of experiment	Result
10 cc. valerianic acid+cotton	1	46 hrs.	No eggs
2 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
5 cc. valerianic acid+cotton+50 cc. water	1	45 hrs.	"
" " " "	1	46 hrs.	"
" " " "	1	23 hrs.	"
" " " "	1	22 hrs.	"
" " " "	1	18 hrs.	"
" " " "	1	3 hrs.	"

Stomoxys did not lay eggs on cotton treated with valerianic acid in these experiments and it was never seen attempting to do so, nor was it ever observed hovering about the dishes.

The odor of two cubic centimeters of the acid diluted with fifty cubic centimeters of water was easily perceptible to a man at a distance of fifteen feet from the dish.

While my results do not agree with Howlett's, this may be due to the fact that we used different methods, or even to some dissimilarity in the responses of *Stomoxys* in the two regions. One can conceive of the same species of insect attuned to respond to certain odors in one environment, responding to very different odors in another.

CONCLUSION.

The odor of ammonia attracts a varied dipterous aggregation. The species which respond to it are known to spend at least a part of their lives in some form of animal excrement. Practically all animal excrement gives off ammonia during some stage in its decomposition. These flies are probably lured to the manure chiefly by the odor of this gas. The response is not always a simple one, but is sometimes complicated by other factors, as has been shown in the studies on *Musca domestica* L. referred to above.

I am indebted to Mr. J. R. Malloch for the identification of several species of Diptera.

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THE SPECIFIC EFFECTS OF CERTAIN LEAF-FEEDING COCCIDAE AND APHIDIDAE UPON THE PINES.

By Kearn B. Brown, Stanford University.

In the great volume of entomological literature, we find but few references dealing with the specific effects of the attacks of sucking insects upon the tissues of their hosts. Statements describing the appearance of the work to the naked eye are, at most, meager in detail; and there are few records of morphological and chemical study of the affected plant tissue and of histological study of the parts of the insects concerned. The present paper summarizes the results of a year's work in the Entomological and Botanical laboratories of Stanford University on a few species of plant-sap sucking insects living on the needles of the pines and the precise character of the results of their work.

Over a year ago we became interested in finding the cause of certain, peculiar, light spots on the needles of the various species of pine found in California, the presence of which has not heretofore been explained. Also, it was noticed that light, greenish-white areas frequently surround scales of *Chionaspis pinifoliæ* Fitch, the white pine scale, and of *Aspidiotus abietis* Schr. (*A. californicus* and *A. florenciæ* Coleman), giving the leaves of a badly infested tree a mottled, sickly appearance. Later, these spots were observed to turn brown, often killing large numbers of the needles. The purpose of this investigation was to find an explanation for these phenomena.

The study of the insects *in situ* is of primary importance in working out this problem. Two methods suggest themselves: (1) observation of the insect at work and of the wounds made on the plant. The latter should be observed immediately after the insect has stopped feeding and at intervals later to determine the ultimate effect of the sucking upon the metabolism of the plant. Another method, (2), is morphological study of the insect and its work by means of sections through the affected tissues and the beak of the insect. Both of these methods have been used in the investigation here summarized.

It has been necessary to develop or adapt several points in microtechnique in order to use the second of these two methods, i. e., morphological study. These points have been discussed in an article* which recently appeared in *Science*.

I. The White Pine Scale, *Chionaspis pinifoliæ* Fitch.

The white pine scale, *Chionaspis pinifoliæ* Fitch, is a conspicuous and widespread pest of pines in North America. It is, as a rule, particularly common on transplanted trees. In the East, the most important host is the white pine, *Pinus strobus*, which it has attacked wherever this pine is grown in North America, often proving a serious pest. It has done great damage to the Monterey pine, *Pinus radiata*, in California.

The white pine scale is entirely a leaf feeder. The flat side of the needles is usually occupied, but in a serious infection the rounded surface is covered as well. As a rule, a single row will be found along a needle, the scales occuring in groups.

As seen in Photograph I, wherever a scale or group of scales occurs, a light colored area with much less chlorophyll than usual is found. It is evident that this is due, primarily, to the sucking of the insects. After many months of sucking, many of the light-colored areas die and dark, reddish spots appear. One of these spots is shown on the upper needle in Photograph I, directly under the scale. Later the needles change from the mottled appearance they have had for some time to a uniform, sickly, yellow color and finally die. Great numbers of the scales are attacked by parasites, but these usually come too late to be of service in checking the damage done by the particular insects they parasitize. It is evident that they partially overcome the enormous increase of which this insect is capable. Lady bird beetles, including *Chilocorus bivulnerus* Muls., the two-stabbed lady bird, are usually of great help.

The amount of damage which a pest does is in direct proportion to its numbers. An insect may be widespread, but it may be held in check so that it is usually of comparatively small importance. Occasionally this species becomes abundant enough to cause great damage. We find that when for any cause the trees are at all weakened, for instance by fire or lack of

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*Brown, Kearn B., Microtechnical Methods for studying certain plant-sucking insects *in situ*. Science, N. S. Vol. XLIV, p. 758, 1916.

sufficient water, the damage from the scales is much more noticeable. It is rarely that trees are actually killed by its attacks.

It is not an easy matter to estimate the amount of damage by such a pest, even when it occurs in such countless numbers as on the Monterey pines at Stanford University. The amount of damage may be estimated by determining the per cent of leaf tissue which has lost its chlorophyll by the sucking and the additional percent of leaf tissue lost by the death of the needles long before their normal time for dying. Our records for *Pinus radiata* in the Stanford arboretum indicate that approximately five per cent of leaf tissue is destroyed in these two ways by *Chionaspis pinifoliæ* Fitch. This injury, together with that caused by the other pests of the Monterey pine, such as *Diplosis pini-radiatæ* Snow and *Physokermes insignicola* Craw so weaken the trees that they fall an easy prey to the Scolytid beetles.

A morphological study of a normal Monterey pine leaf shows its structure to be as follows: On the outside is the epidermis, a single layer of cells through which the stomata, or breathing pores, pass to the tissues underneath. Under the epidermis is the schlerenchyma, a strengthening tissue made up of several layers of heavy-walled cells. Next is the mesophyll with characteristically infolded outer walls, the cells of which contain the chlorophyll granules. There are two resin ducts, one located at a point inside each angle made at the union of the rounded and flat surfaces of the leaf. The resin ducts are surrounded by a double row of resin-secreting cells. Inside the mesophyll is the bundle sheath surrounding the stele with its two parallel vascular bundles. All the tissues described above are shown in Photomicrograph No. II.

Examination of the photomicrographs II and III will show what the insect does to the plant. The four sucking and piercing setæ of the coccid, which are the modified mouthparts of this family, enter the needle either by spreading apart the epidermal cells or at an open stoma. Photograph III shows that schlerenchymatous cells have been bored through. The appearance of the cells around the setæ indicates that this insect, in common with some other members of the family and the *Aphididæ*, uses saliva to dissolve a passage through the hard walls. This section shows that a sheath has been formed around the setæ.

This sheath consists of viscous saliva and passes through the whole of the open space that has been formed by the solvent action of the saliva to a cell that has just been attacked and where fresh saliva has just been poured out to dissolve the cell wall and contents. As soon as a cell has been pierced, its turgor, or pressure from the inside, which is several atmospheres, gives away. The cell's liquid contents is partly forced by the pressure of the surrounding cells and partly leaks out into the open space. It is then sucked up into the insect's body.

Plateau* has shown that the saliva of *Hemiptera* has the power to change starch to sugar. We have proven that this coccid is no exception by the tests made on cells that had just been pierced by the insect. We get negative results with iodin as a test for starch, but Fehling's solution, a test for sugar, gives positive results. The presence of proteid-dissolving and cellulose-dissolving enzymes in the saliva is indicated by the destruction of the cells of the plant by its work. Most of the nutriment is obtained from the mesophyll tissue. This is shown by the number of cells broken up and destroyed or partially destroyed in all of the many sections examined. So we place *Chionaspis pinifoliæ* Fitch in the second class of sucking insects described by Busgen,† "those piercing into the parenchyma by boring through the cells."

It is not possible to say positively whether there is an actual poisoning to the plant by one or more of the enzymes that are injected into its cells. The following evidence points toward such conclusion: The mesophyll tissue is first discolored, then browned and killed, as shown in photomicrograph IV. The killed and discolored mesophyll cells are those shown darkest in the photograph. The mesophyll region near the upper side of the illustration would appear exactly the same as the corresponding area near the lower margin, if the scale had not been sucking in the vicinity of the darkened cells, thereby killing them. This dead tissue extends for a distance much greater than the beak can pierce.

It is not likely that these cells are merely dried out and starved by withdrawal of liquid coming up from the roots, because, so far as it is possible to see, the fibro-vascular bundles are not in any way injured. It is probable that the xylem functions in an infested leaf as in a normal one, supplying water and raw materials.

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*Plateau, Recherches sur les phenomenes de la digestion les insectes. 1874. Bruxelles.

†Busgen, M., Der Honigtau, Jenaische Zeitschrift fur Naturwissenschaft, Bd. 25, p. 381, 1891.

Our research goes to show that one effect on the pines of the work of various insects is only accidental. This is the piercing of the resin duct or of the cells so close to it that the resin becomes infiltrated through a part of the leaf, giving it a white, spotted or banded appearance. That this occurs but rarely in the case of *Chionaspis pinifoliæ* Fitch is explained by the common location of the insects in a single row along the needles, with the beaks entering the leaf tissue at points remote from the resin ducts. In the section shown in photographs II and III, the saliva has dissolved tissue not more than two or three rows of cells distant from the resin duct.

II. *Aspidiotus abietis* Schr.

Another of the economically important *Coccidæ* affecting the conifers is commonly known as the black hemlock or pine scale, *Aspidiotus abietis* Schr. (*A californicus* and *A. florenciæ* Coleman). Observation of trees badly affected by this scale shows that it does great damage at certain times. At Campo Seco, Calaveras, Co., California, we* found it in 1915 the most abundant scale of the region, stunting and killing large numbers of digger pine, *Pinus sabiniana*.

The appearance of *Aspidiotus abietis* Schr. on the trees and the damage it does is shown in photograph V. The damage, a mottling of the needles followed by browning and dying, is similar to that of *Chionaspis pinifoliæ* Fitch. Great numbers of the leaves fall. The remaining leaves are often so sickly looking, or so many are browned, that whole groves of affected trees may look as if a fire had singed the leaves. One noticeable difference from the work of *Chionaspis pinifoliæ* Fitch is the large number of spots which have lost all chlorophyll. These spots are often one-fourth of an inch in length and extend, in some cases, around the needle. These spots will be discussed later as "infiltrated spots."

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*Brown, Kearn B., Rpt. of Entomologist and Pathologist on Pests and Diseases of the Campo Seco, California, Region. 1915.

Morphological study of infested needles shows that the manner of sucking is similar to that described above for *Chionaspis pinifoliæ* Fitch. Photograph VI of the setæ *in situ* in a needle of *Pinus sabiniana* gives an idea of the first stage of the work. Owing to the size of the scale and the shape of the needles of many of the hosts, this scale frequently pierces the resin ducts accidentally. Credit for this discovery is due to Mr. E. A. Cornwall, graduate student in Entomology at Stanford University, who, in preliminary work in this investigation, cut sections showing this. The "infiltrated spots," caused by this tapping of the resin duct, are similar to those due to aphid attacks and shown in photograph VIII. A section of digger pine needle, showing killed cells infiltrated from broken resin duct is shown in photomicrograph VII.

III. *Aphididæ* on Pines.

Several species of *Aphididæ*, or plant lice, infest the pines, including, at Stanford University, *Lachnus pini-radiatæ* Davidson and *Essigella californica* Essig. As but little is known of the effects of conifer-feeding *Aphididæ*, we have made careful, daily observations of these species for a period extending over six weeks. We aimed to find out their habits and to determine, if possible, whether there is any relation between the aphid attacks and three abnormal conditions found on infested needles. Examples are shown in Photograph VIII. They may be described as:

(1) minute white spots;

(2) gumming, apparently from small leaf punctures;

(3) infiltrated spots similar to those described above on page 418. Some of the infiltrated spots show a reddish area in the center of one side, either as a small red mark or as large spots of dead tissue.

Lachnus was found to be a comparatively sedentary species. It seldom removes the beak from the tissues, often remaining in one position for weeks at a time, even in stormy, windy weather. It is conspicuous, usually being found in colonies of two to six apterous females, the progeny of one stem-mother, on one side of the needle. The whole colony is not over an inch in length. The part of the leaf where they are working is covered with gray, waxy secretion. The leaves finally get a coating of black, sooty mold, which grows in the honeydew excreted by the aphids. Both the gray secretion and the sooty mold fungus greatly injure the appearance of infested Monterey pines. Frequently, when a colony of *Lachnus* is rubbed off, small, discolored areas where the beaks have penetrated are disclosed. A large specimen which has been parasitized and killed is shown in Photograph IX. This also shows the final effects of the work, a discoloration of the needle where the insect had sucked. The reddish area extends entirely around the needle. A light green area is shown on either side of this red spot.

Essigella was found to be an active species, the individuals sucking for a day or two in a place, retreating to a protected position at the base of the needle bundles at the slightest disturbance, and also remaining hidden there in wet, windy weather. Detailed, daily observations of all individuals on a number of selected needles were made for a period of six weeks.

Selecting examples at random from our records of *Essigella*, we find that punctures were made during this comparatively short period in 83 places on one leaf, and 74 on another, though the number of aphids on a leaf at the time the observations were made was, on the average, five. Conclusions drawn from the observations are as follows:

(1) Out of about 6400 feeding positions observed, but few left any mark that was visible to the eye, except sooty mold. This was removed at the end of the observation period to make it possible to find any markings there might be beneath.

(2) *Two* feeding positions, in each case of one day only, were followed by an exudation of gum. We made sections to find the cause of the exudation. Both were shown to be caused by a puncturing of the resin ducts. This is apparently accidental, as they would be as poor feeding ground as could be found in the leaf.

(3) *Three* cases of infiltrated spots occurred. One was accompanied by gumming. All were the same as other infiltrated spots found on aphid- or coccid-infested pines.

(4) There were *ten* small, light colored spots which, in every case, followed a period of sucking of two or more days.

Experiments were tried to determine whether infiltrated spots could be produced artificially. Selected digger pine needles were pricked in the region of the resin ducts with Minutien-Nadeln, which are very small needles, commonly used for pinning tiny insects. Effects of the punctures were noted as follows: Out of 20 pricks, *four* showed an exudation of gum. After two weeks two of these gave evidence of infiltration. At the end of the second week, the spots were small. They continued to grow larger.

IV. CONCLUSIONS.

We can say, therefore, that the damage to the needles of pine trees by aphid feeding is:

(1) From the honeydew fungus, which makes the trees unsightly and interferes with the process of photo synthesis, or food manufacture, in the needles by shutting off part of the light;

(2) By discolored areas from which food has been taken and which have been whitened by admission of air to the cells;

(3) By the making of conspicuous, infiltrated spots and causing gum exudation;

(4) Inconspicuous damage by the great number of piercings and suckings. This, though usually invisible, is probably more important than the first three taken together.

The damage to pines by the coccids studied is due to sucking and the enzyme action of the saliva injected to assist in this process. The damage consists of the destruction of chlorophyll-bearing cells with a subsequent whitening of the needles. This is followed by the death of the needles in some cases, or, occasionally, by the production of infiltrated spots that, while conspicuous, are not of great importance.

EXPLANATION OF PLATES XVIII AND XIX.

Fig. 1. Effect of *Chionaspis pinifoliæ* Fitch. On needles of Monterey pine. (x3). On needle above, the red area (very dark in photograph) shows where the beak has punctured. A light green area extends for some distance on either side of this spot. Several of the scales shown in the needle below have been parasitized.

Fig. 2. Photomicrograph of section of Monterey Pine Needle (x60) showing beak of *Chionaspis pinifoliæ* Fitch *in situ* (in open space in upper right hand corner).

Fig. 3. Photomicrograph of beak of *Chionaspis pinifoliæ* Fitch, in section of Monterey pine needle (×360). Same as Photograph II, more highly magnified. The setæ, which form a sheath of saliva as soon as they enter the leaf, are shown in position, also the effect on the leaf tissues. The setæ have entered the leaf on the upper side, passed through the epidermal and schlerenchymatous cells, and entered the mesophyll region. The open space shows that most of the cells have been dissolved, with some of the cell walls not yet completely destroyed, while those on the extreme left of the photograph that are not in direct contact with the saliva are in normal condition. During the preparation of the section, the setæ were accidentally broken from the body of the insect near the point where they entered the leaf tissues.

Fig. 4. Photomicrograph of a longitudinal section of a leaf of Monterey Pine (×60); the mesophyll tissue near the upper margin of the photograph has been killed and discolored by *Chionaspis pinifoliæ* Fitch.

Fig. 5. *Aspidiotus abietis* Schr. on needles of digger pine, showing adult and young scales *in situ* (×3). The light-colored areas on the leaves are the effect of the sucking.

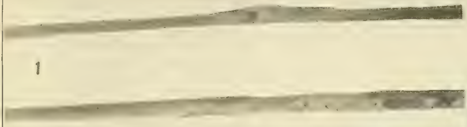
Fig. 6. Photomicrograph of stained section of digger pine leaf (×360), showing beak of *Aspidiotus abietis* Schr. *in situ*. The sucking setæ have just entered the mesophyll tissue, hence no large open space has been dissolved. One cell has been killed. The cell from which the coccid was sucking at the time it was killed and sectioned is partially filled with saliva. A drop of the saliva may be seen near the distal end of the setæ.

Fig. 7. Photomicrograph of a section of digger pine needle (×120) showing killed cells infiltrated from broken resin duct, the large open area a little to the right of the part of the section photographed. All the mesophyll cells above and to the right of the duct have been infiltrated. There is a distinct line separating them from the non-infiltrated area.

Fig. 8. Effects of aphid sucking on digger pine (×3). Needles 1 (on left), 2, 5, and 6 show small, white areas; 2, 3, 4, and 6 show infiltration. The spot on needle 3 is without exudation, but has a red center.

Fig. 9. Parasitized *Lachnus* on Monterey pine needle, with results of sucking. (×3).

Note: In making the plates the author's photographs have been slightly reduced, hence measurements given above are only approximate.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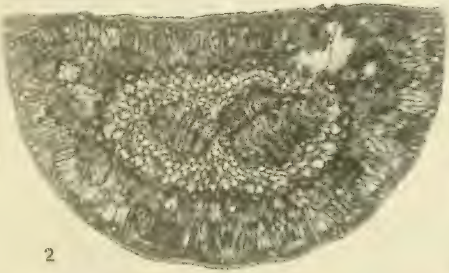
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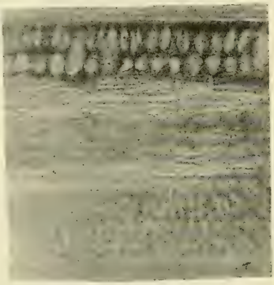
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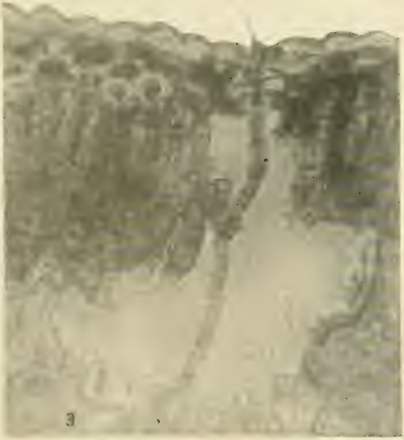
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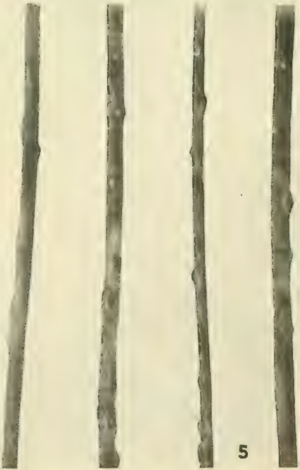
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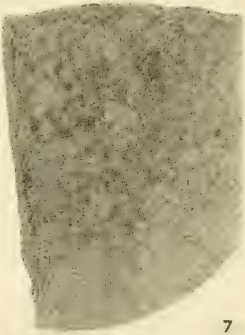

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